Weather Event Simulator

Simulation Guide: *May 31, 1998 Event*

Presented by the

Warning Decision Training Branch

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Warning Decision Training Branch
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Document History

The document history is provided to track updates and changes to the simulation guide. The version number, seen at the bottom of every page will be updated as each significant change is made to the simulation guide.

Version	Date	Description
1.0	30 Apr. 2002	Initial release.

Note: the date of modification is listed on the cover page.

To provide feedback, comments or ideas related to this document, please visit our web site at: http://wdtb.noaa.gov

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1: How to Use This Document

I. Introduction

Welcome to the ***May 31, 1998*** Simulation Guide! The purpose of this guide is to provide the trainer at a forecast office with guidance on preparing and delivering effective severe weather simulations using this case. This guide is being released in accordance with the Weather Event Simulator Integration and Operations Plan (WES IOP).

Since this document outlines the "answers" to the challenges of the event, it is specifically meant for the use of the trainer only.

A simulation can be as simple (view data and practice using WarnGen) or as involved (pause simulation to discuss warning decisions and the impacts of all data on these decisions) as needed. ***The simulation length can be modified depending on the time available for training, the needs of the trainee, and the focus of the training.*** The simulation can focus on the technology alone, the science alone, or the interactions between these two and the human decision maker (i.e. simulating an actual event). This guide is the third in a series of training guides, each associated with specific cases identified in the WES IOP. With this guide, the trainer can summarize the key points of a particular case, choose the type of simulation appropriate for the trainee, and then see an example of how to run that simulation type.

See Table 1-1 for a description of the layout of this document.

Table 1-1: Simulation Guide Layout

How to Use This Document	
Introduction	The introduction describes contents of the simulation guide and how to use this document.
Simulation Types	This section provides a brief, generic description of the various simulation types, some of which are presented in this document. Read this section to help you decide which type of simulation best fits the needs of the trainee (e.g., one which focuses on interpretation skills, or the use of AWIPS, or timing capabilities, or all the above).

Table 1-1: Simulation Guide Layout

The May 31, 1998 Event	
Overview	The event overview provides a summary of the key components of this event. Read this section to get a brief overview of the type of weather or challenges associated with the case.
Prepared Simulations	
First time period: 20 - 22 UTC Interval Based Simulation - Tornado Threat Interval Based Simulation (Severe Threat), Virtual Reality Simulation (Tornado Threat), Virtual Reality Simulation (Severe Threat)	Prepared simulations are provided in this portion of the simulation guide. Each one contains directions on when to start/stop the simulation, objectives, tasks, expected results, and talking points to help hone in on certain features.
Second time period: 22 - 00 UTC Real Time Simulation Interval Based Simulation Situation Awareness Simulation, Virtual Reality Simulation (Geographic Threat)	
Third Time period: 12 - 20 UTC Case Study Simulation	
Supporting Data	
Storm Reports	Storm Reports contains a graphical plot of Storm Data and a text list of Storm Data valid for the simulations.
SPC Products	SPC Products contains graphical plots of the watches/outlooks and text discussion SPC products.
Support Materials	Support Materials contains a CWA map and a useful form for documenting issued warnings and advisories.

To prepare to run a simulation, the trainer should read ***How to Use This Document*** as the background necessary to choose and deliver effective simulations. The trainer may wish to modify the provided simulations, or develop their own simulations with specific learning objectives. The prepared simulations are the "scripts" designed for one-on-one training, where ***trainer and trainee partici-***

pate together for the optimum learning experience. Training research indicates this is the most effective way to run a simulation. Experience gained from running simulations can be used to guide future training activities.

In order to manage a simulation session, the trainer must be able to run a simulation as documented with the WES install and testing instructions included with the WES software. The simulations will be much more relevant if local WarnGen templates and procedures are created on the WES machine or moved over from the local AWIPS prior to running the simulations. For more detailed information on these techniques as they become available, visit http://www.comet.ucar.edu/strc/wes/.

II. Simulation Types

Interval-Based Simulation

An interval-based simulation focuses on detailed discussions of critical warning points utilizing pauses in the simulation. The training objectives are to demonstrate methods of data interpretation, effective use of AWIPS data, proper type and content of warnings, and weighing information in the decision making process. In addition, the trainee should demonstrate ways to handle uncertainty in the warning decision making process.

The objectives of the interval-based simulation are achieved by the **trainer and trainee** working together through a simulation that is occasionally paused to invoke the question-and-answer process. Direct observation of actions taken by the trainee during important decision points during the simulation can provide excellent opportunities for the trainer to discuss applications of effective warning decision making.

Situation Awareness Simulation

A situation awareness simulation focuses on evaluating the trainee's ability to maintain ***three levels of situational awareness***. These are:

1. **Perceive** the warning inputs (*e.g., A spotter reports rotation*),
2. **Comprehend** the meaning of these inputs (*e.g., Together with velocity information, this indicates a high probability of a tornado.*),

3. **Project** this meaning into expectations and action (*e.g., A tornado warning is required along and slightly to the right of the storm's path.*).

For this level of simulation, the trainer will occasionally pause the simulation to query the trainee on interpretation of events. Through this process, the trainer attempts to deduce whether the trainee is maintaining all three levels of situation awareness. The training objective at this level of simulation is to ***demonstrate awareness of the situation***.

As in the interval-based simulation, monitoring of the trainee's level of situation awareness and subsequent decision-making process is only achieved via the trainer's questioning on the methodologies and conceptual models used in the decision-making process.

Virtual Reality Simulation

The virtual reality simulation mode is intended to most closely resemble what can happen in the office for a real event. The training objective of the virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. For example, the trainer might provide conflicting information (spotter reports without supporting radar data) or interject problems (primary radar data unavailable) that the trainee has to react to and overcome during the simulation. This simulation focuses on the highest level of performance and critical thinking skills that should be present with an expert warning forecaster. Running the expert forecasters on staff first through the virtual reality simulation may be a good place to start using WES to enhance a local training plan. Experiences in this simulation can be used to incorporate local knowledge and expertise into future simulations for others forecasters on staff.

Case Study Review

The case study review is appropriate for simulating analysis and manipulation of data sets, including longer-fused events (such as a developing winter storm). Objectives for this type of training depend on the type of event and the forecast problem (boundary analysis, precipitation type forecasting, model initialization, etc.). Training objectives should be based on demonstration and recognition of the strengths and limitations of the various data sets and procedures which are best used to make the watch or warning decision.

The *May 31, 1998* Event

Overview

On the late morning and afternoon of May 31st 1998, a significant severe weather outbreak occurred over New York associated with a strong, mobile surface low embedded in strong zonal flow aloft passing to the north of the state. This was a high risk situation with the potential for significant severe weather, including tornadoes, large hail and severe winds. The 0-6 km wind shear of greater than 40 kts, and the expected instabilities (CAPE > 2000 j/kg), suggested the likely convective mode would be supercells with very large hail. Strong 0-3 km shear of greater than 30 kts and 0-1 km shear around 25 kts, along with low LCLs (1000 m), high 0-3 km Storm Relative Helicity (350 - 400 m^2/s^2) suggested a significant tornado potential for this day.

Severe thunderstorms across western New York were already in progress during the morning. These were associated with the remaining parts of a long-lived severe MCS which produced widespread damage from Minnesota to Michigan and southern Ontario. During the day these storms progressed east while additional storms developed as diurnal heating commenced. Some of these became tornadic supercells. The most notable ones produced large tornadoes with damage tracks up to one half mile wide. In the ALY CWA, the town of Mechanicville was hit by one of these with F3 damage reported. Other tornadoes were reported in both the BGM and ALY CWAs. One long-tracked supercell tornado struck Binghamton and then proceeded eastward for over an hour lifting just prior to reaching Ulster County. Other tornadoes were reported with short squall line segments, one of which touched down at the Albany Airport. In addition to the tornadoes, significant wind damage occurred over most of the CWA with these storms. Large hail was also reported with the supercells. Some of the significant wind episodes occurred in an airmass stabilized by previous convection. This is a testament to the rapid airmass recovery potential as a result of very strong 1-2 km winds. Heavy radar-estimated rainfall totals were observed as there were short periods of training and additional severe storms passed over the same areas as the previous ones. However, there were no significant flash floods reported.

The evolution of convection on this day allows for multiple warning simulations for two different time periods. The simulations for the first time period from 2000

- 2200 UTC have been sectorized by severe weather type. For example, there is an Interval-Based simulation for assessing just the tornado threat and a separate one for all other severe weather threats. However, both simulations cover the entire CWA. For the later time period of 2200 May 31st - 0000 UTC June 1st, there are several simulations more traditionally sectorized by geography. For a plot of storm data and the report list, see Appendix A.

2: Interval Based Simulation - Tornado Threat

I. Introduction

This simulation allows the trainee to develop critical thinking skills. To that end, the trainer and trainee should come to consensus through discussion when arriving at decision points.

This simulation focuses on the unique aspects of handling tornado warning responsibility for a CWA containing numerous storms, one of which produces significant tornadoes (F2-F3 damage), and one that produces a weak tornado (F1 damage) in a metro area. The heavy workload and complicated line segment geometry with merging storms makes this event a good opportunity to sectorize by severe weather type (tornado versus severe) rather than by geography. At various points in the simulation, the WES trainer will pause the simulation and query the trainee about specific learning points. The trainer and trainee should discuss decisions based on the available information and expected outcomes. This simulation is appropriate for a warning forecaster who is proficient at issuing warnings and can benefit from practice handling conflicting information and challenging warning workloads.

Objectives

The training objectives of this interval-based simulation are:

- Demonstrate effective methods of data interpretation.
- Demonstrate proper type and content of warnings.
- Demonstrate how to weigh information and handle uncertainty in the warning decision making process.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Post-simulation Briefing), and V (Trainer Evaluation Guide) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Interrogate the tornado threat for the entire CWA, and issue tornado warnings and follow up statements.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and discuss trainee briefing, and discuss sectorizing issues for this event.

Simulation: Manage the simulation, pause the simulation and discuss important learning issues, and interject spotter reports.

Post-Brief: Discuss trainee performance, any lessons learned from the simulation, and how they can be implemented at the local office.

This interval-based simulation is designed to take 3.5 hours to complete, with 30 minutes for the pre-simulation briefing, 2.0 hours for the simulation, 30 minutes for simulation discussion, and 30 minutes for the post-brief. The simulation starts at 2005 UTC on May 31st, 1998 and ends at 2205 UTC on May 31st, 1998. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sector issues.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 2005 UTC on May 31st, 1998 to 2205 UTC on May 31st, 1998.

4. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

5. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the ALY CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

6. Instruct the trainee to:

- Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA,
- Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.
- Evaluate warning sectorization challenges.

7. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

- 0-6 km shear 50 kts and BRN shear > 40 is supportive of supercell storms.
- Anvil-level SR flow (40 kts) suggests wet-end of classic supercells given isolated initiation.
- Low-level (0-3 km) shear is very strong (40 kts), higher just north of outflow boundary, enhancing supercell tornado potential.
- Midlevel SR flow for right-moving supercells is 20 kts which is favorable for tornadoes.
- Morning soundings indicates a layer of dry air and steep lapse rates suggestive of an Elevated Mixed Layer (EML) at Pittsburgh. The Albany sounding shows elevated moisture surging over a warm frontal boundary.

- Surface dewpoint depressions 15° F or less allow for favorably low LCLs for tornadoes assuming surface dewpoints are well mixed in the boundary layer.
- Midlevel lapse rates are not indicated to be steep and the lack of analyzed midlevel dry air results in theta-E differences < 30° K from the surface to 600 mb. Wet microburst potential is generally low. However, highest potential would be in southern zones with access to dry midlevel air with steep lapse rates evident in the PBZ 12 UTC Skew-T.
- Large hail potential is significant given 20 kt storm-relative midlevel flow, strong shear and high CAPEs. Wet Bulb Zero (WBZ) values (~10.5-11 kft MSL) just above the optimal layer for greatest severe hail threat. Therefore, large hail potential is greatest for supercell storms, and limited for nonsupercells.
- Short-duration, heavy rain potential heightened due to storms realizing the high CAPE, and deep moisture. Rapid storm motion will minimize prolonged heavy rainfall. “Corfidi” vector motion is low suggesting that if a MCC does form, prolonged heavy rain potential is possible.
- In addition, high midlevel lapse rates are likely residing in the southern half of the CWA. LAPS is not depicting these lapse rates.

8. Discuss the warning sector issues, and have the trainee sectorize by severe weather type (tornado) for this scenario. The trainee will be responsible for evaluating the tornado threat for the whole CWA. When the trainee deems a tornado warning is necessary, a warning should be issued, and the trainee will be responsible for handling all warning responsibility for that storm.

9. Make sure the trainee is comparing direct observations with any LAPS, or other diagnostic model output.

10. Inform the trainee that the flash flood guidance for the ALY CWA is approximately 2” for one hour, and 3” for three hours.

11. Point out on the SPC products provided in Appendix B that the CWA is in a high risk area, and a tornado watch has been issued with a threat for tornadoes, hail to 2 inches in diameter, and wind gusts to 70 kts.

III. Simulation

The training objectives of this interval-based simulation are to demonstrate effective methods of data interpretation, demonstrate proper type and content of warnings, and demonstrate how to weigh information and handle uncertainty in the warning decision making process. This simulation starts at 2005 UTC on May 31st, 1998 and ends at 2205 UTC on May 31st, 1998. At three times during the simulation (2020, 2040, 2124 UTC; unknown to the trainee), the simulation will be paused and the trainer will assess the trainee's warnings and methodology. Discussion is encouraged. For a storm-by-storm breakdown of important features in the data (both tornado and severe) and important evaluation points (both tornado and severe), consult the Trainer Evaluation Guide on page 2-7.

Trainer Tasks

1. Explain the objectives to the trainee (see page 2-1).

2. State to the trainee that:

- There will be three pauses managed by the trainer, at surprise times, each lasting up to 10 minutes during the two hour simulation, at which times the trainer will query the trainee about their warnings and their methodology.
- The trainee will be responsible for interrogating the tornado threat (CWA wide) and creating tornado warnings and follow on statements. When a storm’s threat is transitioning from severe to tornado, the trainee may ask the trainer for input on the severe evaluation (wind, hail, and flooding) if necessary.
- The trainer will be forwarding spotter reports to the trainee during the simulation.

3. Close down any existing D2D sessions, and start the simulation for the time period 2005 UTC on May 31st, 1998 to 2205 UTC on May 31st, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

4. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under “File”, “Export to File...”.
- Type in the name of the warning at the end of the path in the “filename” box on the bottom of the popup window and click OK.

5. Give the trainee 5-10 minutes to set up their D2D sessions.

6. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide (consult Appendix A for graphical locations).

7. At 2020 UTC pause the simulation for up to 10 minutes and ask:

(1) “What are the current tornado warnings out and why?”

(2) “What is the expectation of these storms in the next 30 minutes?”

Get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Discuss the reasoning with the trainee and try to reach a consensus on the warning decision. Some considerations for discussion points include:

- the level of threat for tornadoes, particularly for the strong mesocyclone in Saratoga County at this time,
- product choice,
- warning composition details,
- environmental analysis, and
- uncertainty in the decision making process.

8. Resume Simulation.

9. At 2040 UTC pause the simulation for up to 10 minutes and repeat **Step 7**. At this time pay particular attention to the tornado reported in Albany County as well as the signature in Washington-Rensselaer Counties.

10. Resume Simulation.

11. At 2114 UTC pause the simulation for up to 10 minutes and repeat **Step 7**. At this time pay particular attention to the TDA detection in northeast Rensselaer County and the data quality issues.

12. At the end the simulation, give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objectives of the post simulation briefing are to summarize the successes and failures of the warning process, and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation completed during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- Recognizing rapidly evolving mesocyclones and tornadoes.
- Handling tornado reports in highly populated areas when radar signatures are ambiguous.
- Maintaining a high level of situation awareness throughout.
- Optimal usage of base data analysis with radar derived products and algorithms.
- Optimal sectorization.

Trainer Tasks

1. Ask the trainee to:

- Discuss the strengths and weaknesses of the data used in the decision making as well as the approach to analyzing the data.
- Discuss any problems encountered with determining the type or content of the warnings.
- Discuss the challenges of synthesizing the warning inputs and the sources of uncertainty.

2. Review the reports and the times to compare to the warnings.

3. Discuss the lessons learned from the event, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. The evaluation of the trainee by the trainer is to be done while the trainee is actively involved in the warning operations. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation. Note this section contains information on both the tornado and severe threats for each storm. For this simulation the trainer should focus on the evaluation points relevant to the tornado threat.

General Issues

Time (UTC)	Description
1801-0557 KBGM	radar data time period (limited radar products)
2002-0034 KENX	radar data time period (full set of radar products)
prior to 2053 KENX	OHP data not available (This is an artifact of the process of developing this case.)
2043 KENX	widespread dealiasing failures aloft

Considerations

- Does the trainee anticipate the general threat of severe weather to shift more to the south due to the initial storm geometry and the better instability over this area?
- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?
- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, and LAPS)?
- Does the trainee recognize the bands of weak reflectivity east of the radar are associated with the mountains, and that the velocity data is being contaminated in this area?
- Does the trainee recognize the cone of silence significantly affects the ability to determine many middle and upper-level storm characteristics for many of the important storms passing over the radar?

Storm Summary

During the simulation there are numerous areas requiring detailed monitoring for severe weather in the CWA. The first area to monitor includes a cluster of cells in the Hudson River Valley in Saratoga County (referenced in the cell table below as **“Saratoga-Washington-Rensselaer-Bennington-Windham County Storm Cluster”**). The initial radar signatures (radar data starts at 2002 UTC) suggest large hail and damaging winds are the primary threat with these cells. Hail up to golf ball size and wind gusts to 52 kts are reported first with the cell cluster. Radar reflectivities are high (70 dBZ, VIL 70+ kg/m2) and base velocities starting from 2007 UTC show a large area of 50-64 kt winds on the south side of the cell cluster that correlates well with the subsequent 52 kt damaging wind report and the eventual mesocyclone formation/intensification. General wind damage is also reported with the cell cluster as the primary threat shifts rapidly to tornado.

In the first few volume scans of the simulation the mesocyclone rapidly intensifies over Saratoga County with strong rotation above 5 Kft. No gate-to-gate signature precedes the tornado, and the first TDA detection occurs with the tornado at 2022 UTC. The storm produces tornadoes with generally F2 and some F3 damage nearly continuously from 2022 - 2055. Strong gate-gate shears exist through much of the tornadoes lifetimes, however there are a couple of volume scans near the end of the tornado damage where the radar observed shears are weak while the tornado is still doing significant damage. Early in the tornado development, one of the cells in the cluster intensifies to the southwest of the tornado, generating heavy rain near the tornado. The cluster of cells eventually transitions to an HP supercell structure with much of the heavy precipitation around the tornado and on the back side of the storm. The tornado damage reports end as the storm gradually weakens and moves east out of the valley into the higher terrain where the CAPE is analyzed to be less.

Another area with impending severe weather at the start of the simulation is located in the mountains just west of the CWA. Two storms (referenced below as **Otsego-Schoharie County “Northern” Storm (1947-2038)** and **Cortland-Chenango-Otsego-Schoharie-Albany County “Southern” Storm (1927-2053)**) move out of Otsego county in the BGM CWA where they produced severe weather. The “northern” storm in Otsego County at the start of the simulation evolved from an east-west oriented line of storms that produced widespread wind damage in the northern part of Otsego county. No severe weather was reported from this storm when it evolved from the line, though radar shows a threat existed during this time. The KBGM and KENX radars suggests the tornado threat was low from this storm due to a lack of organized rotation. KENX reflectivities are relatively high (60 dBZ, VIL 55 kg/m2) at 2002 UTC suggesting a severe hail threat early. Both radars show a broad area of 50-64 kt ground-relative winds in lower levels, suggesting a damaging wind threat. The base velocity data from KENX shows these winds well ahead of the higher reflectivities at

2002 UTC, suggesting an upshear tilted updraft undercut by outflow, and the storm may have been heavily influenced by its strong cold pool. The storm becomes difficult to track around 2038 UTC when it merges with other storms, and it enters the variable terrain on the western side of the Hudson River Valley.

The “southern” storm in Otsego County at the start of the simulation evolved from the tail end of a line segment that is first seen in the KBGM data at 1927 UTC. The storm exhibits bow echo characteristics from both KBGM and KENX prior to the wind damage reports. Both radars show widespread areas of 50-64 kt wind in lower levels though the KBGM radar shows 64+ kt velocities earlier than the KENX radar. The KENX perspective shows classic bow echo signatures with an elevated rear inflow jet and strong mid-altitude radial convergence at 2017 UTC. From the start of the simulation, the storm moves at 70 kts. The storm apparently produced widespread wind damage in Otsego County (report times appear off) in the BGM CWA including downed trees, power lines, transmission towers, and blocked roads with 1 fatality due to a large tree limb falling in Oneonta. The storm apparently produced a brief, weak tornado (F0 damage, report time appears off) in northeast Delaware County, though radar does not show well defined cyclonic rotation or a gate-to-gate signature in this area. The KENX radar briefly showed some high reflectivity (60 dBZ, 55 kg/m2 VIL) and updraft intensification at 2027 UTC, suggesting a brief severe hail threat. As the storm moved into the ALY CWA, it produced general wind damage before passing over the radar and entering the Hudson River Valley. While in the valley, the storm merged with the other convection, whereby it became difficult to isolate around 2053 UTC. From 2048 UTC onward, the storms in this area combine into a large line and are referred to as **Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)**.

Another area to monitor in the early part of the simulation is in the northeast part of the CWA (referred to in the storm tables below as **Saratoga-Washington County Storm (2012-2048)**). A storm with weak reflectivities develops minimal to moderate strength mesocyclone rotational velocities in western Washington County at 2022 UTC. No severe weather is reported with this storm, and it weakens when it moves into the mountains east of the Hudson River Valley.

Another area to monitor for severe weather in the early part of the simulation is very close to the radar in the central part of the CWA. A brief F1 tornado occurs in the Albany metro area at 2037 UTC. The tornado comes from a small line segment very close to the radar that has sampling limitations due to the radar cone of silence. A minimal to moderate strength mesocyclone develops a couple of volume scans before the tornado, though the development is easy to overlook with the large number of storms and the other areas to monitor. The radar does not show a well-defined gate-gate signature or a clear tornado-scale “second velocity peak” with this tornado despite the close range (perhaps at longer range this small mesocyclone may have shown up as a gate-gate signature). The tornado passed close to the surface observation which has the tornado in the remark and a measured wind gust of 71 kts from the northwest. The updraft intensifies as it moves east, and it merges with surrounding storms.

Numerous severe storms merge to form a solid line around 2048 UTC (referred to in the storm tables below as **Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)**). This line develops classic bow echo signatures, and it produces widespread wind damage in the CWA. Large areas of 64+ kt ground-relative velocity are measured by the radar in low-levels along with an elevated rear-inflow jet. While wind damage is prevalent along the line, the southern portion of the solid line contains a very strong updraft where reflectivities and VIL are maximized. Severe hail is an additional threat in the southern part of the line, though no severe hail is reported with the bow echo. There is no organized cyclonic rotation with the bow echo so the supercell tornado threat is low. The TDA does trigger twice on bad data in ground clutter and noisy data in an area of anticyclonic shear.

The final area to monitor is the storm just southwest of the bow echo. The storm quickly develops high reflectivities/VIL on radar at 2038 UTC in Greene County. The strongest hail signatures occur as the storm moves into Columbia County. At times the hail algorithm predicts maximum sizes to be 3.75”, though the largest size hail reported was golf ball. No reports were within the low-level reflectivity maximum, so the hail sizes may have been larger in some areas. One wind damage report exists around the time of the most intense updraft signatures, though base velocities did not show a large area of strong low-level winds until later in the storm’s life. Though the storm contained strong updraft signatures, the radar did not detect organized rotation, suggesting the tornado threat is low with this storm. The base velocity data in low-levels shows that the storm is riding along and behind the damaging wind-producing boundary being laid out by the bow echo. The positioning of the isolated storm’s gust front out ahead of the radar echo along with the lack of organized persistent inflow, suggests the storm may have been adversely affected by this boundary.

Saratoga-Washington-Rensselaer-Bennington-Windham County Storm Cluster

Time (UTC)	Description
2002 KENX	70 kg/m2 VIL, 60dBZ to 31Kft, 70dBZ at 0.5 degrees, 1.75” MEHS, large area of 50-64 kt winds at 4500 ft AGL on south flank of storms, two distinct storm tops, storm located in the valley where channeling of wind may occur (Saratoga County)
2012 KENX	strong rotation (45 kt V_r) above 5Kft rapidly develops, large area of 64+ kt ground-relative winds at 5Kft in mesocyclone (Saratoga County)
2015	LSR ALY#8: 1” hail Milton Center (Saratoga County)
2016	LSR ALY#9: G52 Mechanicville (Saratoga County)
2017 KENX	rotation continues to intensify (V_r nearly 50kts), coverage of 64+kt velocities increase and is coincident with higher reflectivities (Saratoga County)
2020	LSR ALY#10: 1.75” hail Saratoga Springs, note: radar data doesn’t match time of report (Saratoga County)
2022 KENX	2022 strong and deep TVS with 105 kt LLDV (TVS persists through 2038)
2022	LSR ALY#11: F3 tornado 0.7 NNE Ushers to 1 NNE Mechanicville, tornado damage through 2027 (Saratoga County)
2027 KENX	precipitation from line is seeding the parent storm marking the early stage of transition to HP supercell characteristics (Washington-Rensselaer Counties)
2027	LSR ALY#12: F2 tornado 1.9 NNW Reynolds to 2.6 ENE Walloomsac, tornado damage through 2045 (Rensselaer County)
2030	LSR ALY#14: thunderstorm wind damage in Cambridge (Washington County)
2032	LSR ALY#16: thunderstorm wind damage in Arlington, note radar data does not match time of report (Bennington County)
2033 KENX	reflectivity aloft increases (55dBZ to 33 Kft) (Washington-Rensselaer Counties)
2035	LSR ALY#18: 0.75” hail Ballston Spa, note: radar data doesn’t match time of report (Saratoga County)
2038 KENX	HP supercell characteristics, updraft (Washington-Rensselaer Counties)

Time (UTC)	Description
2043 KENX	De-aliasing failure above 1.5 degrees
2045	LSR ALY#22: F2 tornado crosses county line 1.7 WNW North Bennington to 2 ESE South Shaftsbury, tornado damage through 2055 (Bennington County)
2048 KENX	reflectivity aloft weakens significantly, VIL drops to 40 kg/m2
2058 KENX	weak TVS algorithm detection with poor time and height continuity in the base data

Considerations

- Does the trainee recognize that this storm has the highest threat of severe weather at the start of the simulation?
- Does the trainee recognize the initial large hail threat and multi-cell characteristics of this storm?
- Does the trainee recognize the rapid development of strong rotation in the 2012 UTC volume scan?
- Is a tornado warning issued before the TVS algorithm detects the tornado at 2022 UTC?
- Is the threat for large hail and strong winds included with tornado threat in the warning products?
- Is specific information about the location and movement of the tornado included in the warning products?
- Does the trainee recognize the shift to HP supercell characteristics, and do the warning products contain any information about the likelihood of the tornado being embedded in heavy precipitation?
- Does the trainee recognize the longer term trend of the storm moving into more stable air and higher terrain?

Otsego-Schoharie County “Northern” Storm 1947-2038)

Time (UTC)	Description
1930	LSR BGM#1: widespread wind damage in northern Otsego County from other storms in the line (through 1940); Trees and wires were blown down in Cooperstown and northern Burlington Flats between 3:30 and 3:40 EDT. Several roads were blocked due to the downed trees and wires. People were trapped in their vehicles by falling trees and some sustained injury from flying debris, broken glass, or falling wires. (Otsego County)
1958 KBGM	broad region of 50-64 kt base velocity at 5-6 Kft
2002 KENX	55 dBZ to 32 kft, MEHS 1.5”, 55 kg/m2 VIL, small areas of 50-64 kt ground-relative velocity at 2.4 Kft, 0.5 degree base velocity indicates storm undercut by outflow with gust front far ahead of main echo, storm located over the mountains
2007 KENX	reflectivities aloft weaken significantly, VIL decrease to 40 kg/m2
2038 KENX	radar echo difficult to isolate

Considerations

- Does the trainee consider sampling the storm from the BGM radar to get another perspective?
- Does the trainee recognize the rapid collapse of the storm that begins ~ 2007 UTC?
- Does the trainee recognize the primary threat shifts quickly from large hail to more damaging winds as the storm collapses?

Otsego-Schoharie-Albany County “Southern” Storm (1927-2053)

Time (UTC)	Description
2002 KENX	large area of 50-64 kt ground-relative velocity at 4.5 Kft, storm located over the mountains
2007 KENX	STI product shows 70+ kt storm motion for cell E0 (through 2022)
2013 KBGM	significant area of 64+ kt ground relative wind at 3.7 Kft (0.5 degree V)

Time (UTC)	Description
2017 KENX	line segment consolidating with elevated rear-inflow jet signature ~ 10Kft (2.4 degree SRM) and strong mid-altitude radial convergence, manual storm motion of 70 kts
2023 KBGM	areal increase of 64+ kt base velocity at 0.5 degrees
2027 KENX	60 dBZ to 30 Kft, VIL increases to 55 kg/m2, 1.75” MEHS, cell id changes which corrupts storm motion in STI product
2030	LSR ALY#13: thunderstorm wind damage in North Blenheim (Schoharie County)
2030	LSR BGM#5: thunderstorm wind damage in eastern Otsego County (through 2050), note time does not match the radar data; Trees and wires were blown down in Cooperstown and Laurens between 4:30 and 4:35 PM EDT. Numerous trees and wires were also downed by the wind in Schenevus at 4:45 pm and Oneonta at 4:50 pm EDT. Transmission towers and large signs were also toppled in Oneonta. Numerous roads were blocked due to the downed trees and many of them were closed for several hours. In Oneonta, a 32 year-old man was struck and killed by a large tree limb. Several additional injuries were sustained from flying debris.(Otsego County)
2032	LSR ALY#15: thunderstorm wind damage in Middleburgh (Schoharie County)
2033 KENX	50 kg/m2 VIL on second updraft core on tail end of storm
2043 KENX	64+ kt base velocity very close to the radar
2045	LSR BGM#8: F0 tornado Davenport to Fergusonville (note times do not match radar data); The tornado cut a discontinuous 3 mile path from Davenport Township northeastward through Butts Corners to Fergusonville between 4:45 and 4:55 EDT. The twister appeared to skip across mainly hilltop sections. large trees were twisted and snapped off on ridge tops with tree damage mainly confined to canopy level at somewhat lower elevations. In Butts Corners, several homes near the path of the tornado sustained siding and roof damage. The tornado appeared to lift back into the cloud base just north of Route 9 in Fergusonville. (Delaware County)
2053 KENX	radar echo difficult to isolate

Considerations

- Does the trainee recognize the Otsego County storm warrants interrogation before it enters the CWA?
- Does the trainee consider using the KBGM radar to interrogate the storm?
- Does the trainee recognize the persistent fast storm motions of 70 knots early in the radar data?
- Does the trainee utilize this quantitative information appropriately in the warning (correct storm motion and stronger or more detailed wording of damaging wind threat)?
- Does the trainee recognize the strong updraft signatures in the KENX data at 2027 UTC, and that the severe hail threat briefly increases as well?
- Does the trainee recognize the detection of strong winds over the radar?

Saratoga-Washington County Storm 2012-2048)

Time (UTC)	Description
2022 KENX	minimal-moderate rotation (V_r 30 kts) in western Washington County
2002 KENX	weak 40 kt delta V at 1.5 degree SRM

Considerations

- Does the trainee recognize this storm has developed rotation though the reflectivity structure is not impressive?

Schoharie-Schenectady-Albany County Line (2007-2048)

Time (UTC)	Description
2010	LSR ALY#7: thunderstorm wind damage in Schoharie, note: base velocity data correlates better with a storm to the west at ~ 2025 UTC.
2027 KENX	minimal mesocyclone best defined below 7Kft
2033 KENX	moderate mesocyclone (V_r 35 kts) above 11 Kft
2037	LSR ALY#19: F1 tornado 1.7 NNW Colony to 0.7 WNW Latham (through 2041 UTC) (Albany County)

Time (UTC)	Description
2040	LSR ALY#21: G71 Albany Airport (Albany County)
2043 KENX	55 dBZ to 30 Kft, 60 kg/m2 VIL

Considerations

- Does the trainee recognize the line of storms over the radar is being poorly sampled by the radar due to the cone of silence?
- Does the trainee recognize the minimal to moderate strength mesocyclone?
- Although the tornado is not well defined in the radar data due to a lack of a strong shear signature, does the trainee still consider the report as being potentially credible in association with the mesocyclone?

Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)

Time (UTC)	Description
2048 KENX	larger area of 64+ kt base velocities at 2Kft AGL as storms begin to merge into a line (high base velocity measurements become persistent in lower levels)
2050	LSR ALY#23: thunderstorm wind damage in Colonie (Albany County)
2050	LSR ALY#24: thunderstorm wind damage in Rotterdam (Schenectady County)
2050	LSR ALY#25: thunderstorm wind damage in Schenectady (Schenectady County)
2058 KENX	large area of 60 dBZ at 30 Kft at the top of the cone of silence, 60 kg/m2 VIL,1.75-2“MEHS (through 2114), elevated rear-inflow jet becomes better visible at 9 Kft in 4panel Z/SRM as storm moves east of radar
2100	LSR ALY#27: thunderstorm wind damage in Brunswick (Rensselaer County)
2103 KENX	55 dBZ to 35 Kft, large area of 65 kg/m2 VIL
2105	LSR ALY#28: thunderstorm wind damage in East Greenbush (Rensselaer County)

Time (UTC)	Description
2105	LSR ALY#29: thunderstorm wind damage in Bennington (Bennington County)
2108 KENX	TVS algorithm triggers off of de-aliasing failure in ground clutter on elevated terrain
2110	LSR ALY#30: thunderstorm wind damage in Kinderhook (Columbia County)
2110	LSR ALY#31: thunderstorm wind damage in Stuyvesant (Columbia County)
2114 KENX	elevated rear inflow jet visible at 6 Kft (1.5 degree V) as line structure becomes highly linear, structure is persistent, 55 dBZ to 40 Kft, 70+ kg/m2 VIL, line motion is east at 55 kts
2120	LSR ALY#32: thunderstorm wind damage in Chatham (Columbia County)
2129 KENX	60 dBZ to 32 Kft
2135	LSR ALY#35: thunderstorm wind damage in Nassau, note: radar data doesn't match time of report (Rensselaer County)
2139 KENX	weak TVS algorithm detection in area of noisy velocity data with no temporal or height continuity; primary velocity pattern in area is anticyclonic shear
2142	LSR ALY#36: thunderstorm wind damage in Brattleboro (Windham County)
2149 KENX	reflectivity structure and VIL (35 kg/m2) weaken
2154 KENX	Primary updraft in line weakens significantly

Considerations

- Does the trainee recognize the widespread velocities of 64+ knots in lower levels as the storms begin to merge?
- Does the trainee recognize the elevated reflectivity cores with the stronger updraft areas in the line, indicating a higher probability of severe hail?
- Does the trainee recognize the mature bow-echo characteristics as the line of storms becomes more linear?
- Does the trainee recognize the ground clutter contaminating the velocity estimates at 0.5 degrees?

- If the trainee observes the TVS algorithm detection at 2108, does the trainee put less significance to the detection because of the velocity de-aliasing failure in the ground clutter?
- If the trainee observes the 2139 TVS algorithm detection, does the trainee put less significance to the detection because of the noisy data, the lack of temporal and height continuity, and the general velocity pattern being one of anticyclonic shear?

Greene-Albany-Columbia-Berkshire-Hampshire-Franklin County Storm

Time (UTC)	Description
2038 KENX	65 dBZ at 18Kft, 55 kg/m2 VIL, 2” MEHS (1.75+ estimates through 2149)
2043 KENX	70 dBZ at 18Kft
2048 KENX	VIL weakens to 40 kg/m2
2100	LSR ALY#26: 1” hail in Greeneville (Greene County)
2108 KENX	65 dBZ at 0.5 degrees
2114 KENX	large area of 55 kg/m2 VIL intensifies
2119 KENX	70 dBZ to 27 Kft, 60 dBZ to 32 Kft entering the radar cone of silence, 65 kg/m2 VIL, 3.75” MEHS (2.5”+ through 2139)
2124 KENX	70+ kg/m2 VIL
2126	LSR ALY#33: thunderstorm wind damage in Niverville (Columbia County)
2129 KENX	large area of 65 dBZ in the lowest three radar tilts (< 8Kft), three-body scatter spike at 1.5 degrees
2131	LSR ALY#34: 1” hail in Stuyvesant, note: time does not match radar data (Columbia County)
2134 KENX	larger area of 50-64 kt base velocity
2144 KENX	64+ kt base velocities at 3 Kft
2145	LSR ALY#37: 1.75” hail in Pittsfield (Berkshire County)
2154 KENX	1.8-2” OHP estimates with orientation of line becoming more parallel to storm motion
2200 KENX	VIL weakens to 40 kg/m2

Considerations

- Does the trainee recognize the early threat for severe hail by diagnosing elevated reflectivity cores?
- Does the trainee use enhanced wording in the warning products to describe the hail threat with the persistent severe hail signatures in the base data?
- Does the trainee use the Hail Index algorithm output in estimating hail size in the warnings, or are sizes estimated based on analysis of base data along with storm reports?
- Does the trainee recognize the boundary being laid out by the bow echo that is intersecting the storm?
- Does the trainee recognize the base velocity data shows the strong boundary has surged out ahead of the storm?
- Does the trainee recognize the storm is having a difficult time developing organized, strong inflow, and that the velocity data suggests the storm updraft has been “undercut” by outflow?
- Does the trainee recognize the lack of organized rotation throughout the storm’s life decreases the tornado threat?
- Does the trainee recognize the appearance of higher base velocities around 2134-2144?
- Does the trainee recognize the probability of severe winds increases with the detection of 50 and 64 kt winds in lower levels?
- Does the trainee occasionally monitor the radar precipitation estimates even though it is not the primary severe weather threat?
- Does the trainee recognize the flash flooding threat increases as the line becomes more east-west oriented, parallel to storm motion?
- Does the trainee consider that the precipitation is likely overestimated in areas where hail signatures exist?

3: Interval Based Simulation (Severe Threat)

I. Introduction

This simulation allows the trainee to develop critical thinking skills. To that end, the trainer and trainee should come to consensus through discussion when arriving at decision points.

This simulation focuses on the unique aspects of handling severe thunderstorm warning responsibility for a CWA containing numerous storms. The heavy workload and complicated line segment geometry makes this event a good opportunity to sectorize by severe weather type (severe versus tornado) rather than by geography. At various points in the simulation, the WES trainer will pause the simulation and query the trainee about specific learning points. The trainer and trainee should discuss decisions based on the available information and expected outcomes. This simulation is appropriate for a warning forecaster who is proficient at issuing warnings and can benefit from practice handling conflicting information and challenging warning workloads.

Objectives

The training objectives of this interval-based simulation are:

- Demonstrate effective methods of data interpretation.
- Demonstrate proper type and content of warnings.
- Demonstrate how to weigh information and handle uncertainty in the warning decision making process.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Post-simulation Briefing), and V (Trainer Evaluation Guide) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Interrogate the severe thunderstorm threat (wind, hail, and flash flooding) for the entire CWA, and issue severe thunderstorm warnings and follow up statements.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and discuss trainee briefing, and discuss sectorizing issues for this event.

Simulation: Manage the simulation, pause the simulation and discuss important learning issues, and interject spotter reports.

Post-Brief: Discuss trainee performance, any lessons learned from the simulation, and how they can be implemented at the local office.

This interval-based simulation is designed to take 3.5 hours to complete, with 30 minutes for the pre-simulation briefing, 2.0 hours for the simulation, 30 minutes for simulation discussion, and 30 minutes for the post-brief. The simulation starts at 2005 UTC on May 31st, 1998 and ends at 2205 UTC on May 31st, 1998. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sector issues.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 2005 UTC on May 31st, 1998 to 2205 UTC on May 31st, 1998.

4. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

5. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the ALY CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

6. Instruct the trainee to:

- Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA,
- Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.
- Evaluate warning sectorization challenges.

7. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

- 0-6 km shear 50 kts and BRN shear > 40 is supportive of supercell storms.
- Anvil-level SR flow (40 kts) suggests wet-end of classic supercells given isolated initiation.
- Low-level (0-3 km) shear is very strong (40 kts), higher just north of outflow boundary, enhancing supercell tornado potential.
- Midlevel SR flow for right-moving supercells is 20 kts which is favorable for tornadoes.

- Morning soundings indicates a layer of dry air and steep lapse rates suggestive of an Elevated Mixed Layer (EML) at Pittsburgh. The Albany sounding shows elevated moisture surging over a warm frontal boundary.
- Surface dewpoint depressions 15° F or less allow for favorably low LCLs for tornadoes assuming surface dewpoints are well mixed in the boundary layer.
- Midlevel lapse rates are not indicated to be steep and the lack of analyzed midlevel dry air results in theta-E differences < 30° K from the surface to 600 mb. Wet microburst potential is generally low. However, highest potential would be in southern zones with access to dry midlevel air with steep lapse rates evident in the PBZ 12 UTC Skew-T.
- Large hail potential is significant given 20 kt storm-relative midlevel flow, strong shear and high CAPEs. Wet Bulb Zero (WBZ) values (~10.5-11 kft MSL) just above the optimal layer for greatest severe hail threat. Therefore, large hail potential is greatest for supercell storms, and limited for nonsupercells.
- Short-duration, heavy rain potential heightened due to storms realizing the high CAPE, and deep moisture. Rapid storm motion will minimize prolonged heavy rainfall. “Corfidi” vector motion is low suggesting that if a MCC does form, prolonged heavy rain potential is possible.
- In addition, high midlevel lapse rates are likely residing in the southern half of the CWA. LAPS is not depicting these lapse rates.

8. Discuss the warning sector issues, and have the trainee sectorize by severe weather type (severe) for this scenario. The trainee will be responsible for evaluating the severe threat (hail, wind, flooding) for the whole CWA.The trainer will inform the trainee when a tornado warning is going to be issued. As long as the tornado warning is in effect, the trainee will not issue severe thunderstorm warnings for that storm, though they should still interrogate the severe thunderstorm threat for all storms.

9. Make sure the trainee is comparing direct observations with any LAPS, or other diagnostic model output.

10. Inform the trainee that the flash flood guidance for the ALY CWA is approximately 2” for one hour, and 3” for three hours.

11. Point out on the SPC products provided in Appendix B that the CWA is in a high risk area, and a tornado watch has been issued with a threat for tornadoes, hail to 2 inches in diameter, and wind gusts to 70 kts.

III. Simulation

The training objectives of this interval-based simulation are to demonstrate effective methods of data interpretation, demonstrate proper type and content of warnings, and demonstrate how to weigh information and handle uncertainty in the warning decision making process. This simulation starts at 2005 UTC on May 31st, 1998 and ends at 2205 UTC on May 31st, 1998. At three times during the simulation (2030, 2103, 2124 UTC; unknown to the trainee), the simulation will be paused and the trainer will assess the trainee's warnings and methodology. Discussion is encouraged. For a storm-by-storm breakdown of important features (both severe and tornado) in the data and important evaluation points (both severe and tornado), consult the Trainer Evaluation Guide on page 3-8.

Trainer Tasks

1. Explain the objectives to the trainee (see page 3-1).

2. State to the trainee that:

- There will be three pauses managed by the trainer, at surprise times, each lasting up to 10 minutes during the two hour simulation, at which times the trainer will query the trainee about their warnings and their methodology.
- The trainee will be responsible for interrogating the severe thunderstorm threat (CWA wide) and creating severe thunderstorm warnings and follow on statements. When a storm's threat is transitioning from severe to tornado, the trainer will inform the trainee, and at that point the trainee will not create warnings for that storm, though they should still monitor the severe thunderstorm threat if they have time.
- The trainer will be forwarding spotter reports to the trainee during the simulation.

3. Close down any existing D2D sessions, and start the simulation for the time period 2005 UTC on May 31st, 1998 to 2205 UTC on May 31st, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

4. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under “File”, “Export to File...”.

- Type in the name of the warning at the end of the path in the “filename” box on the bottom of the popup window and click OK.

5. Give the trainee 5-10 minutes to set up their D2D sessions.

6. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide (consult Appendix A for graphical locations).

7. At 2020 UTC inform the trainee that the cluster of cells with strong rotation in southern Saratoga County is going to have a tornado warning issued. The trainee should provide the trainer with all hail, wind, and flooding threat information at this time that can be included in the tornado warning.

8. At 2030 UTC pause the simulation for up to 10 minutes and ask:

(1) “What are the current severe thunderstorm warnings out and why?”

(2) “What is the expectation of these storms in the next 30 minutes?”

Get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Discuss the reasoning with the trainee and try to reach a consensus on the warning decision. Some considerations for discussion points include:

- the level of threat for all severe weather types,
- product choice,
- warning composition details,
- radar sampling issues,
- environmental analysis, and
- uncertainty in the decision making process.

9. Resume Simulation.

10. At 2040 UTC inform the trainee of that a tornado has been reported in northeast Albany County near Colony. The tornado warning forecaster is going to issue a tornado warning, and they would like to know what kind of severe threats have been mentioned previously with this storm.

11. At 2103 UTC pause the simulation for up to 10 minutes and repeat **Step 8**.

12. Resume Simulation.

13. At 2124 UTC pause the simulation for up to 10 minutes and repeat **Step 8**.

14. At the end of the simulation, give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objectives of the post simulation briefing are to summarize the successes and failures of the warning process, and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation completed during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- Recognizing rapidly evolving mesocyclones and tornadoes.
- Handling tornado reports in highly populated areas when radar signatures are ambiguous.
- Maintaining a high level of situation awareness throughout.
- Optimal usage of base data analysis with radar derived products and algorithms.
- Optimal sectorization.

Trainer Tasks

1. Ask the trainee to:

- Discuss the strengths and weaknesses of the data used in the decision making as well as the approach to analyzing the data.
- Discuss any problems encountered with determining the type or content of the warnings.
- Discuss the challenges of synthesizing the warning inputs and the sources of uncertainty.

2. Review the reports and the times to compare to the warnings.

3. Discuss the lessons learned from the event, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. The evaluation of the trainee by the trainer is to be done while the trainee is actively involved in the warning operations. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation. Note this section contains information on both the severe and tornado threats for each storm. For this simulation the trainer should focus on the evaluation points relevant to the severe threat.

General Issues

Time (UTC)	Description
1801-0557 KBGM	radar data time period (limited radar products)
2002-0034 KENX	radar data time period (full set of radar products)
prior to 2053 KENX	OHP data not available (This is an artifact of the process of developing this case.)
2043 KENX	widespread dealiasing failures aloft

Considerations

- Does the trainee anticipate the general threat of severe weather to shift more to the south due to the initial storm geometry and the better instability over this area?
- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?
- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, and LAPS)?

- Does the trainee recognize the bands of weak reflectivity east of the radar are associated with the mountains, and that the velocity data is being contaminated in this area?
- Does the trainee recognize the cone of silence significantly affects the ability to determine many middle and upper-level storm characteristics for many of the important storms passing over the radar?

Storm Summary

During the simulation there are numerous areas requiring detailed monitoring for severe weather in the CWA. The first area to monitor includes a cluster of cells in the Hudson River Valley in Saratoga County (referenced in the cell table below as **“Saratoga-Washington-Rensselaer-Bennington-Windham County Storm Cluster”**). The initial radar signatures (radar data starts at 2002 UTC) suggest large hail and damaging winds are the primary threat with these cells. Hail up to golf ball size and wind gusts to 52 kts are reported first with the cell cluster. Radar reflectivities are high (70 dBZ, VIL 70+ kg/m2) and base velocities starting from 2007 UTC show a large area of 50-64 kt winds on the south side of the cell cluster that correlates well with the subsequent 52 kt damaging wind report and the eventual mesocyclone formation/intensification. General wind damage is also reported with the cell cluster as the primary threat shifts rapidly to tornado.

In the first few volume scans of the simulation the mesocyclone rapidly intensifies over Saratoga County with strong rotation above 5 Kft. No gate-to-gate signature precedes the tornado, and the first TDA detection occurs with the tornado at 2022 UTC. The storm produces tornadoes with generally F2 and some F3 damage nearly continuously from 2022 - 2055. Strong gate-gate shears exist through much of the tornadoes lifetimes, however there are a couple of volume scans near the end of the tornado damage where the radar observed shears are weak while the tornado is still doing significant damage. Early in the tornado development, one of the cells in the cluster intensifies to the southwest of the tornado, generating heavy rain near the tornado. The cluster of cells eventually transitions to an HP supercell structure with much of the heavy precipitation around the tornado and on the back side of the storm. The tornado damage reports end as the storm gradually weakens and moves east out of the valley into the higher terrain where the CAPE is analyzed to be less.

Another area with impending severe weather at the start of the simulation is located in the mountains just west of the CWA. Two storms (referenced below as **Otsego-Schoharie County "Northern" Storm (1947-2038)** and **Cortland-Chenango-Otsego-Schoharie-Albany County "Southern" Storm (1927-2053)**) move out of Otsego county in the BGM CWA where they produced severe weather. The "northern" storm in Otsego County at the start of the simulation evolved from an east-west oriented line of storms that produced widespread wind damage in the northern part of Otsego county. No severe weather was reported from this storm when it evolved from the line, though radar shows a threat existed during this time. The KBGM and KENX radars suggests the tornado threat was low from this storm due to a lack of organized rotation. KENX reflectivities are relatively high (60 dBZ, VIL 55 kg/m2) at 2002 UTC suggesting a severe hail threat early. Both radars show a broad area of 50-64 kt ground-relative winds in lower levels, suggesting a damaging wind threat. The base velocity data from KENX shows these winds well ahead of the higher reflectivities at 2002 UTC, suggesting an upshear tilted updraft undercut by outflow, and the storm may have been heavily influenced by its strong cold pool. The storm becomes difficult to track around 2038 UTC when it merges with other storms, and it enters the variable terrain on the western side of the Hudson River Valley.

The "southern" storm in Otsego County at the start of the simulation evolved from the tail end of a line segment that is first seen in the KBGM data at 1927 UTC. The storm exhibits bow echo characteristics from both KBGM and KENX prior to the wind damage reports. Both radars show widespread areas of 50-64 kt wind in lower levels though the KBGM radar shows 64+ kt velocities earlier than the KENX radar. The KENX perspective shows classic bow echo signatures with an elevated rear inflow jet and strong mid-altitude radial convergence at 2017 UTC. From the start of the simulation, the storm moves at 70 kts. The storm apparently produced widespread wind damage in Otsego County (report times appear off) in the BGM CWA including downed trees, power lines, transmission towers, and blocked roads with 1 fatality due to a large tree limb falling in Oneonta. The storm apparently produced a brief, weak tornado (F0 damage, report time appears off) in northeast Delaware County, though radar does not show well defined cyclonic rotation or a gate-to-gate signature in this area. The KENX radar briefly showed some high reflectivity (60 dBZ, 55 kg/m2 VIL) and updraft intensification at 2027 UTC, suggesting a brief severe hail threat. As the storm moved into the ALY CWA, it produced general wind damage before passing over the radar and entering the Hudson River Valley. While in the valley, the storm merged with the other convection, whereby it became difficult to isolate around 2053 UTC. From 2048 UTC onward, the storms in this area combine into a large line and are referred to as **Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)**.

Another area to monitor in the early part of the simulation is in the northeast part of the CWA (referred to in the storm tables below as **Saratoga-Washington County Storm (2012-2048)**). A storm with weak reflectivities develops minimal to moderate strength mesocyclone rotational velocities in western Washington County at 2022 UTC. No severe weather is reported with this storm, and it weakens when it moves into the mountains east of the Hudson River Valley.

Another area to monitor for severe weather in the early part of the simulation is very close to the radar in the central part of the CWA. A brief F1 tornado occurs in the Albany metro area at 2037 UTC. The tornado comes from a small line segment very close to the radar that has sampling limitations due to the radar cone of silence. A minimal to moderate strength mesocyclone develops a couple of volume scans before the tornado, though the development is easy to overlook with the large number of storms and the other areas to monitor. The radar does not show a well-defined gate-gate signature or a clear tornado-scale “second velocity peak” with this tornado despite the close range (perhaps at longer range this small mesocyclone may have shown up as a gate-gate signature). The tornado passed close to the surface observation which has the tornado in the remark and a measured wind gust of 71 kts from the northwest. The updraft intensifies as it moves east, and it merges with surrounding storms.

Numerous severe storms merge to form a solid line around 2048 UTC (referred to in the storm tables below as **Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)**). This line develops classic bow echo signatures, and it produces widespread wind damage in the CWA. Large areas of 64+ kt ground-relative velocity are measured by the radar in low-levels along with an elevated rear-inflow jet. While wind damage is prevalent along the line, the southern portion of the solid line contains a very strong updraft where reflectivities and VIL are maximized. Severe hail is an additional threat in the southern part of the line, though no severe hail is reported with the bow echo. There is no organized cyclonic rotation with the bow echo so the supercell tornado threat is low. The TDA does trigger twice on bad data in ground clutter and noisy data in an area of anticyclonic shear.

The final area to monitor is the storm just southwest of the bow echo. The storm quickly develops high reflectivities/VIL on radar at 2038 UTC in Greene County. The strongest hail signatures occur as the storm moves into Columbia County. At times the hail algorithm predicts maximum sizes to be 3.75”, though the largest size hail reported was golf ball. No reports were within the low-level reflectivity maximum, so the hail sizes may have been larger in some areas. One wind damage report exists around the time of the most intense updraft signatures, though base velocities did not show a large area of strong low-level winds until later in the storm’s life. Though the storm contained strong updraft signatures, the radar did not detect organized rotation, suggesting the tornado threat is low with this storm. The base velocity data in low-levels shows that the storm is riding along and behind the damaging wind-producing boundary being laid out by the bow echo. The positioning of the isolated storm’s gust front out ahead of the radar echo along with the lack of organized persistent inflow, suggests the storm may have been adversely affected by this boundary.

Saratoga-Washington-Rensselaer-Bennington-Windham County Storm Cluster

Time (UTC)	Description
2002 KENX	70 kg/m2 VIL, 60dBZ to 31Kft, 70dBZ at 0.5 degrees, 1.75” MEHS, large area of 50-64 kt winds at 4500 ft AGL on south flank of storms, two distinct storm tops, storm located in the valley where channeling of wind may occur (Saratoga County)
2012 KENX	strong rotation (45 kt V_r) above 5Kft rapidly develops, large area of 64+ kt ground-relative winds at 5Kft in mesocyclone (Saratoga County)
2015	LSR ALY#8: 1” hail Milton Center (Saratoga County)
2016	LSR ALY#9: G52 Mechanicville (Saratoga County)
2017 KENX	rotation continues to intensify (V_r nearly 50kts), coverage of 64+kt velocities increase and is coincident with higher reflectivities (Saratoga County)
2020	LSR ALY#10: 1.75” hail Saratoga Springs, note: radar data doesn’t match time of report (Saratoga County)
2022 KENX	2022 strong and deep TVS with 105 kt LLDV (TVS persists through 2038)
2022	LSR ALY#11: F3 tornado 0.7 NNE Ushers to 1 NNE Mechanicville, tornado damage through 2027 (Saratoga County)

Time (UTC)	Description
2027 KENX	precipitation from line is seeding the parent storm marking the early stage of transition to HP supercell characteristics (Washington-Rensselaer Counties)
2027	LSR ALY#12: F2 tornado 1.9 NNW Reynolds to 2.6 ENE Walloomsac, tornado damage through 2045 (Rensselaer County)
2030	LSR ALY#14: thunderstorm wind damage in Cambridge (Washington County)
2032	LSR ALY#16: thunderstorm wind damage in Arlington, note radar data does not match time of report (Bennington County)
2033 KENX	reflectivity aloft increases (55dBZ to 33 Kft) (Washington-Rensselaer Counties)
2035	LSR ALY#18: 0.75" hail Ballston Spa, note: radar data doesn't match time of report (Saratoga County)
2038 KENX	HP supercell characteristics, updraft (Washington-Rensselaer Counties)
2043 KENX	De-aliasing failure above 1.5 degrees
2045	LSR ALY#22: F2 tornado crosses county line 1.7 WNW North Bennington to 2 ESE South Shaftsbury, tornado damage through 2055 (Bennington County)
2048 KENX	reflectivity aloft weakens significantly, VIL drops to 40 kg/m2
2058 KENX	weak TVS algorithm detection with poor time and height continuity in the base data

Considerations

- Does the trainee recognize that this storm has the highest threat of severe weather at the start of the simulation?
- Does the trainee recognize the initial large hail threat and multi-cell characteristics of this storm?
- Does the trainee recognize the rapid development of strong rotation in the 2012 UTC volume scan?
- Is a tornado warning issued before the TVS algorithm detects the tornado at 2022 UTC?
- Is the threat for large hail and strong winds included with tornado threat in the warning products?

- Is specific information about the location and movement of the tornado included in the warning products?
- Does the trainee recognize the shift to HP supercell characteristics, and do the warning products contain any information about the likelihood of the tornado being embedded in heavy precipitation?
- Does the trainee recognize the longer term trend of the storm moving into more stable air and higher terrain?

Otsego-Schoharie County “Northern” Storm 1947-2038)

Time (UTC)	Description
1930	LSR BGM#1: widespread wind damage in northern Otsego County from other storms in the line (through 1940); Trees and wires were blown down in Cooperstown and northern Burlington Flats between 3:30 and 3:40 EDT. Several roads were blocked due to the downed trees and wires. People were trapped in their vehicles by falling trees and some sustained injury from flying debris, broken glass, or falling wires. (Otsego County)
1958 KBGM	broad region of 50-64 kt base velocity at 5-6 Kft
2002 KENX	55 dBZ to 32 kft, MEHS 1.5”, 55 kg/m2 VIL, small areas of 50-64 kt ground-relative velocity at 2.4 Kft, 0.5 degree base velocity indicates storm undercut by outflow with gust front far ahead of main echo, storm located over the mountains
2007 KENX	reflectivities aloft weaken significantly, VIL decrease to 40 kg/m2
2038 KENX	radar echo difficult to isolate

Considerations

- Does the trainee consider sampling the storm from the BGM radar to get another perspective?
- Does the trainee recognize the rapid collapse of the storm that begins ~ 2007 UTC?
- Does the trainee recognize the primary threat shifts quickly from large hail to more damaging winds as the storm collapses?

Otsego-Schoharie-Albany County "Southern" Storm (1927-2053)

Time (UTC)	Description
2002 KENX	large area of 50-64 kt ground-relative velocity at 4.5 Kft, storm located over the mountains
2007 KENX	STI product shows 70+ kt storm motion for cell E0 (through 2022)
2013 KBGM	significant area of 64+ kt ground relative wind at 3.7 Kft (0.5 degree V)
2017 KENX	line segment consolidating with elevated rear-inflow jet signature ~ 10Kft (2.4 degree SRM) and strong mid-altitude radial convergence, manual storm motion of 70 kts
2023 KBGM	areal increase of 64+ kt base velocity at 0.5 degrees
2027 KENX	60 dBZ to 30 Kft, VIL increases to 55 kg/m2, 1.75" MEHS, cell id changes which corrupts storm motion in STI product
2030	LSR ALY#13: thunderstorm wind damage in North Blenheim (Schoharie County)
2030	LSR BGM#5: thunderstorm wind damage in eastern Otsego County (through 2050), note time does not match the radar data; Trees and wires were blown down in Cooperstown and Laurens between 4:30 and 4:35 PM EDT. Numerous trees and wires were also downed by the wind in Schenevus at 4:45 pm and Oneonta at 4:50 pm EDT. Transmission towers and large signs were also toppled in Oneonta. Numerous roads were blocked due to the downed trees and many of them were closed for several hours. In Oneonta, a 32 year-old man was struck and killed by a large tree limb. Several additional injuries were sustained from flying debris.(Otsego County)
2032	LSR ALY#15: thunderstorm wind damage in Middleburgh (Schoharie County)
2033 KENX	50 kg/m2 VIL on second updraft core on tail end of storm
2043 KENX	64+ kt base velocity very close to the radar

Time (UTC)	Description
2045	LSR BGM#8: F0 tornado Davenport to Fergusonville (note times do not match radar data); The tornado cut a discontinuous 3 mile path from Davenport Township northeastward through Butts Corners to Fergusonville between 4:45 and 4:55 EDT. The twister appeared to skip across mainly hilltop sections. large trees were twisted and snapped off on ridge tops with tree damage mainly confined to canopy level at somewhat lower elevations. In Butts Corners, several homes near the path of the tornado sustained siding and roof damage. The tornado appeared to lift back into the cloud base just north of Route 9 in Fergusonville. (Delaware County)
2053 KENX	radar echo difficult to isolate

Considerations

- Does the trainee recognize the Otsego County storm warrants interrogation before it enters the CWA?
- Does the trainee consider using the KBGM radar to interrogate the storm?
- Does the trainee recognize the persistent fast storm motions of 70 knots early in the radar data?
- Does the trainee utilize this quantitative information appropriately in the warning (correct storm motion and stronger or more detailed wording of damaging wind threat)?
- Does the trainee recognize the strong updraft signatures in the KENX data at 2027 UTC, and that the severe hail threat briefly increases as well?
- Does the trainee recognize the detection of strong winds over the radar?

Saratoga-Washington County Storm 2012-2048)

Time (UTC)	Description
2022 KENX	minimal-moderate rotation (V_r 30 kts) in western Washington County
2002 KENX	weak 40 kt delta V at 1.5 degree SRM

Considerations

- Does the trainee recognize this storm has developed rotation though the reflectivity structure is not impressive?

Schoharie-Schenectedy-Albany County Line (2007-2048)

Time (UTC)	Description
2010	LSR ALY#7: thunderstorm wind damage in Schoharie, note: base velocity data correlates better with a storm to the west at ~ 2025 UTC.
2027 KENX	minimal mesocyclone best defined below 7Kft
2033 KENX	moderate mesocyclone (V_r 35 kts) above 11 Kft
2037	LSR ALY#19: F1 tornado 1.7 NNW Colony to 0.7 WNW Latham (through 2041 UTC) (Albany County)
2040	LSR ALY#21: G71 Albany Airport (Albany County)
2043 KENX	55 dBZ to 30 Kft, 60 kg/m2 VIL

Considerations

- Does the trainee recognize the line of storms over the radar is being poorly sampled by the radar due to the cone of silence?
- Does the trainee recognize the minimal to moderate strength mesocyclone?
- Although the tornado is not well defined in the radar data due to a lack of a strong shear signature, does the trainee still consider the report as being potentially credible in association with the mesocyclone?

Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)

Time (UTC)	Description
2048 KENX	larger area of 64+ kt base velocities at 2Kft AGL as storms begin to merge into a line (high base velocity measurements become persistent in lower levels)
2050	LSR ALY#23: thunderstorm wind damage in Colonie (Albany County)

Time (UTC)	Description
2050	LSR ALY#24: thunderstorm wind damage in Rotterdam (Schenectady County)
2050	LSR ALY#25: thunderstorm wind damage in Schenectady (Schenectady County)
2058 KENX	large area of 60 dBZ at 30 Kft at the top of the cone of silence, 60 kg/m2 VIL,1.75-2“MEHS (through 2114), elevated rear-inflow jet becomes better visible at 9 Kft in 4panel Z/SRM as storm moves east of radar
2100	LSR ALY#27: thunderstorm wind damage in Brunswick (Rensselaer County)
2103 KENX	55 dBZ to 35 Kft, large area of 65 kg/m2 VIL
2105	LSR ALY#28: thunderstorm wind damage in East Greenbush (Rensselaer County)
2105	LSR ALY#29: thunderstorm wind damage in Bennington (Bennington County)
2108 KENX	TVS algorithm triggers off of de-aliasing failure in ground clutter on elevated terrain
2110	LSR ALY#30: thunderstorm wind damage in Kinderhook (Columbia County)
2110	LSR ALY#31: thunderstorm wind damage in Stuyvesant (Columbia County)
2114 KENX	elevated rear inflow jet visible at 6 Kft (1.5 degree V) as line structure becomes highly linear, structure is persistent, 55 dBZ to 40 Kft, 70+ kg/m2 VIL, line motion is east at 55 kts
2120	LSR ALY#32: thunderstorm wind damage in Chatham (Columbia County)
2129 KENX	60 dBZ to 32 Kft
2135	LSR ALY#35: thunderstorm wind damage in Nassau, note: radar data doesn’t match time of report (Rensselaer County)
2139 KENX	weak TVS algorithm detection in area of noisy velocity data with no temporal or height continuity; primary velocity pattern in area is anticyclonic shear
2142	LSR ALY#36: thunderstorm wind damage in Brattleboro (Windham County)
2149 KENX	reflectivity structure and VIL (35 kg/m2) weaken

Time (UTC)	Description
2154 KENX	Primary updraft in line weakens significantly

Considerations

- Does the trainee recognize the widespread velocities of 64+ knots in lower levels as the storms begin to merge?
- Does the trainee recognize the elevated reflectivity cores with the stronger updraft areas in the line, indicating a higher probability of severe hail?
- Does the trainee recognize the mature bow-echo characteristics as the line of storms becomes more linear?
- Does the trainee recognize the ground clutter contaminating the velocity estimates at 0.5 degrees?
- If the trainee observes the TVS algorithm detection at 2108, does the trainee put less significance to the detection because of the velocity de-aliasing failure in the ground clutter?
- If the trainee observes the 2139 TVS algorithm detection, does the trainee put less significance to the detection because of the noisy data, the lack of temporal and height continuity, and the general velocity pattern being one of anticyclonic shear?

Greene-Albany-Columbia-Berkshire-Hampshire-Franklin County Storm

Time (UTC)	Description
2038 KENX	65 dBZ at 18Kft, 55 kg/m2 VIL, 2” MEHS (1.75+ estimates through 2149)
2043 KENX	70 dBZ at 18Kft
2048 KENX	VIL weakens to 40 kg/m2
2100	LSR ALY#26: 1” hail in Greeneville (Greene County)
2108 KENX	65 dBZ at 0.5 degrees
2114 KENX	large area of 55 kg/m2 VIL intensifies
2119 KENX	70 dBZ to 27 Kft, 60 dBZ to 32 Kft entering the radar cone of silence, 65 kg/m2 VIL, 3.75” MEHS (2.5”+ through 2139)
2124 KENX	70+ kg/m2 VIL

Time (UTC)	Description
2126	LSR ALY#33: thunderstorm wind damage in Niverville (Columbia County)
2129 KENX	large area of 65 dBZ in the lowest three radar tilts (< 8Kft), three-body scatter spike at 1.5 degrees
2131	LSR ALY#34: 1” hail in Stuyvesant, note: time does not match radar data (Columbia County)
2134 KENX	larger area of 50-64 kt base velocity
2144 KENX	64+ kt base velocities at 3 Kft
2145	LSR ALY#37: 1.75” hail in Pittsfield (Berkshire County)
2154 KENX	1.8-2” OHP estimates with orientation of line becoming more parallel to storm motion
2200 KENX	VIL weakens to 40 kg/m2

Considerations

- Does the trainee recognize the early threat for severe hail by diagnosing elevated reflectivity cores?
- Does the trainee use enhanced wording in the warning products to describe the hail threat with the persistent severe hail signatures in the base data?
- Does the trainee use the Hail Index algorithm output in estimating hail size in the warnings, or are sizes estimated based on analysis of base data along with storm reports?
- Does the trainee recognize the boundary being laid out by the bow echo that is intersecting the storm?
- Does the trainee recognize the base velocity data shows the strong boundary has surged out ahead of the storm?
- Does the trainee recognize the storm is having a difficult time developing organized, strong inflow, and that the velocity data suggests the storm updraft has been “undercut” by outflow?
- Does the trainee recognize the lack of organized rotation throughout the storm’s life decreases the tornado threat?
- Does the trainee recognize the appearance of higher base velocities around 2134-2144?

- Does the trainee recognize the probability of severe winds increases with the detection of 50 and 64 kt winds in lower levels?
- Does the trainee occasionally monitor the radar precipitation estimates even though it is not the primary severe weather threat?
- Does the trainee recognize the flash flooding threat increases as the line becomes more east-west oriented, parallel to storm motion?
- Does the trainee consider that the precipitation is likely overestimated in areas where hail signatures exist?

4: Virtual Reality Simulation (Tornado Threat)

I. Introduction

This simulation focuses on the unique aspects of handling tornado warning responsibility for a CWA containing numerous storms, one of which produces significant tornadoes (F2-F3 damage), and one that produces a weak tornado (F1 damage) in a metro area. The heavy workload and complicated line segment geometry make this event a good opportunity to sectorize by severe weather type (tornado versus severe) rather than by geography. This simulation is appropriate for an experienced warning forecaster who is proficient with the mechanics of issuing warnings and can benefit from practicing warning workload management.

Objective

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Trainer Evaluation Guide), and V (Post-simulation Briefing) have been designed for a two-person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Interrogate the tornado threat for the entire CWA, and issue tornado warnings and follow up statements.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and document trainee briefing, and discuss sectorizing issues for this event.

Simulation: Manage the simulation, evaluate the performance of the trainee, and interject information such as spotter reports, special forecast requests, and any type of challenges that can happen in a real event (be creative!).

Post-Brief: Discuss trainee performance and any lessons learned from the simulation and how they can be implemented at the local office.

This virtual reality simulation is designed to take 3 hours to complete, with 30 minutes for the pre-simulation briefing, 2 hours for the simulation, and 30 minutes for the post-brief. The simulation starts at 2005 UTC on May 31st, 1998 and ends at 2205 UTC on May 31st, 1998. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sector issues.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 2005 UTC on May 31st, 1998 to 2205 UTC on May 31st, 1998.

4. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

5. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the ALY CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

6. Instruct the trainee to:

- Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA.
- Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.
- Evaluate warning sectorization challenges.

7. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

- 0-6 km shear 50 kts and BRN shear > 40 is supportive of supercell storms.
- Anvil-level SR flow (40 kts) suggests wet-end of classic supercells given isolated initiation.
- Low-level (0-3 km) shear is very strong (40 kts), higher just north of outflow boundary, enhancing supercell tornado potential.
- Midlevel SR flow for right-moving supercells is 20 kts which is favorable for tornadoes.
- Morning soundings indicates a layer of dry air and steep lapse rates suggestive of an Elevated Mixed Layer (EML) at Pittsburgh. The Albany sounding shows elevated moisture surging over a warm frontal boundary.
- Surface dewpoint depressions 15° F or less allow for favorably low LCLs for tornadoes assuming surface dewpoints are well mixed in the boundary layer.
- Midlevel lapse rates are not indicated to be steep and the lack of analyzed midlevel dry air results in theta-E differences < 30° K from the surface to 600 mb. Wet microburst potential is generally low. However, highest potential would be in southern zones with access to dry midlevel air with steep lapse rates evident in the PBZ 12 UTC Skew-T.

- Large hail potential is significant given 20 kt storm-relative midlevel flow, strong shear and high CAPEs. Wet Bulb Zero (WBZ) values (~10.5-11 kft MSL) just above the optimal layer for greatest severe hail threat. Therefore, large hail potential is greatest for supercell storms, and limited for nonsupercells.
- Short-duration, heavy rain potential heightened due to storms realizing the high CAPE, and deep moisture. Rapid storm motion will minimize prolonged heavy rainfall. “Corfidi” vector motion is low suggesting that if a MCC does form, prolonged heavy rain potential is possible.
- In addition, high midlevel lapse rates are likely residing in the southern half of the CWA. LAPS is not depicting these lapse rates.

8. Discuss the warning sector issues, and have the trainee sectorize by severe weather type (tornado) for this scenario. The trainee will be responsible for evaluating the tornado threat for the whole CWA. When the trainee deems a tornado warning is necessary, a warning should be issued, and the trainee will be responsible for handling all warning responsibility for that storm.

9. Make sure the trainee is comparing direct observations with any LAPS, or other diagnostic model output.

10. Inform the trainee that the flash flood guidance for the ALY CWA is approximately 2” for one hour, and 3” for three hours.

11. Point out on the SPC products provided in Appendix B that the CWA is in a high risk area, and a tornado watch has been issued with a threat for tornadoes, hail to 2 inches in diameter, and wind gusts to 70 kts.

III. Simulation

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. This 2 hour simulation starts at 2005 UTC on May 31st, 1998, and ends at 2205 UTC on May 31st, 1998. For a storm-by-storm breakdown of important features (both tornado and severe) in the data and important evaluation points (both tornado and severe), consult the Trainer Evaluation Guide on page 4-7.

Trainer Tasks

1. State to the trainee:

- The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products.
- The trainee will be responsible for interrogating the tornado threat (CWA wide) and creating tornado warnings and follow on statements. This is another way to sectorize in order to better distribute workload. This may be particularly useful when sectorizing by geography or by storms is not manageable. The trainee is to assume the severe threat is being covered by someone else. When a storm's threat is transitioning from severe to tornado, the trainee may ask the trainer for input on the severe evaluation if necessary.
- There will be no pauses during the 2 hour simulation (plan accordingly).
- The trainee should communicate any sectorizing issues/confusion with the trainer during the event.
- The trainer will be forwarding spotter reports to the trainee during the simulation.

2. Close down any existing D2D sessions, and start the simulation for the time period 2005 UTC on May 31st, 1998 to 2205 UTC on May 31st, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

3. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under "File", "Export to File...".
- Type in the name of the warning at the end of the path in the "filename" box on the bottom of the popup window and click OK.

4. Give the trainee 5-10 minutes to set up their D2D sessions.

5. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide on page 4-7 (consult image in Appendix A for graphical locations), and make up conflicting spotter reports during the simulation to determine if the trainee is evaluating the reports well. Any other incoming calls or distractions should be interjected as to simulate a real environment. This could include briefings to EMS, toxic spills, failure for a warning to transmit, etc.

6. At 2016 UTC consider giving a distracting request. The Saratoga County emergency manager has called from Mechanicville with some wind damage (estimated gusts to 60 MPH). The Mechanicville Arts and Crafts festival is going on, and people are going indoors to get away from the wind. He wants to know how much longer the winds are going to last. Evaluate the trainee's ability to effectively answer the request in a timely manner, including whether the response mentions all potential severe weather threats.

7. At 2037 UTC consider giving a distracting request. The safety officer at the Albany International Airport has called because of a tornado report he has received near Colony in northeast Albany County. He wants to know what you see on radar because he is considering closing the airport. Evaluate the trainee's ability to respond to the request in a timely manner and how the trainee responds to the information.

8. At 2101 consider giving a leading report. The Rensselaer County Sheriff has called with a report of strong rotation in the clouds south of East Greenbush in southwest Rensselaer County. Evaluate how the trainee responds to this information and whether the trainee recognizes the rotation is anticyclonic and therefore poses less of a threat for tornadoes.

9. At 2120 UTC consider disrupting the warning operations. Simulate a D2D crash or spontaneous logout. ***Do not stop the simulator.*** Either have the trainee exit and restart D2D, or have the trainee stop using D2D temporarily and explain how they would recover. Evaluate the trainee's ability to recover from the disruption.

10. At 2144 UTC consider giving a distracting request. The neighboring CWA to the east (BOX) is on the phone needing some assistance in evaluating the tornado threat in Franklin County. They are not receiving any products from the KENX radar, and the Franklin County emergency manager has called them wanting an update on the tornado threat for Shelburne Falls (west central Franklin County). A TV station out of Springfield, MA is showing a NEXRAD Tornado Vortex Signature from the KENX radar over Shelburne Falls, and the emergency manager wants to know if he should sound the sirens for the surrounding area. Evaluate the trainee's ability to effectively answer the request in a timely manner.

11. At the end of the simulation, give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objective of the post simulation briefing is to summarize the successes and failures of the warning process and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation done during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- Handling stress and workload so as to keep the effective flow of information going.
- Off-loading tasks as necessary.
- Maintaining the big picture issues while periodically focussing on the details.
- Maintaining a high level of situation awareness throughout.
- Recognizing rapidly evolving mesocyclones and tornadoes.
- Handling tornado reports in highly populated areas when radar signatures are ambiguous.
- Optimal usage of base data analysis with radar derived products and algorithms.
- Optimal sectorization.

Trainer Tasks

1. Ask the trainee to:
   - Discuss challenges in managing the warning workload.
   - Discuss any problems encountered with responding to the disruptions in the warning environment.

2. Review the reports and the times to compare to the warnings.

3. Discuss the lessons learned from the event, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. The evaluation of the trainee by the trainer is to be done while the trainee is actively involved in the warning operations. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation. Note this section contains information on both the tornado and severe threats for each storm. For this simulation the trainer should focus on the evaluation points relevant to the tornado threat.

General Issues

Time (UTC)	Description
1801-0557 KBGM	radar data time period (limited radar products)
2002-0034 KENX	radar data time period (full set of radar products)
prior to 2053 KENX	OHP data not available (This is an artifact of the process of developing this case.)
2043 KENX	widespread dealiasing failures aloft

Considerations

- Does the trainee anticipate the general threat of severe weather to shift more to the south due to the initial storm geometry and the better instability over this area?
- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?
- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, and LAPS)?
- Does the trainee recognize the bands of weak reflectivity east of the radar are associated with the mountains, and that the velocity data is being contaminated in this area?

- Does the trainee recognize the cone of silence significantly affects the ability to determine many middle and upper-level storm characteristics for many of the important storms passing over the radar?

Storm Summary

During the simulation there are numerous areas requiring detailed monitoring for severe weather in the CWA. The first area to monitor includes a cluster of cells in the Hudson River Valley in Saratoga County (referenced in the cell table below as **“Saratoga-Washington-Rensselaer-Bennington-Windham County Storm Cluster”**). The initial radar signatures (radar data starts at 2002 UTC) suggest large hail and damaging winds are the primary threat with these cells. Hail up to golf ball size and wind gusts to 52 kts are reported first with the cell cluster. Radar reflectivities are high (70 dBZ, VIL 70+ kg/m2) and base velocities starting from 2007 UTC show a large area of 50-64 kt winds on the south side of the cell cluster that correlates well with the subsequent 52 kt damaging wind report and the eventual mesocyclone formation/intensification. General wind damage is also reported with the cell cluster as the primary threat shifts rapidly to tornado.

In the first few volume scans of the simulation the mesocyclone rapidly intensifies over Saratoga County with strong rotation above 5 Kft. No gate-to-gate signature precedes the tornado, and the first TDA detection occurs with the tornado at 2022 UTC. The storm produces tornadoes with generally F2 and some F3 damage nearly continuously from 2022 - 2055. Strong gate-gate shears exist through much of the tornadoes lifetimes, however there are a couple of volume scans near the end of the tornado damage where the radar observed shears are weak while the tornado is still doing significant damage. Early in the tornado development, one of the cells in the cluster intensifies to the southwest of the tornado, generating heavy rain near the tornado. The cluster of cells eventually transitions to an HP supercell structure with much of the heavy precipitation around the tornado and on the back side of the storm. The tornado damage reports end as the storm gradually weakens and moves east out of the valley into the higher terrain where the CAPE is analyzed to be less.

Another area with impending severe weather at the start of the simulation is located in the mountains just west of the CWA. Two storms (referenced below as **Otsego-Schoharie County “Northern” Storm (1947-2038)** and **Cortland-Chenango-Otsego-Schoharie-Albany County “Southern” Storm (1927-**

2053)) move out of Otsego county in the BGM CWA where they produced severe weather. The “northern” storm in Otsego County at the start of the simulation evolved from an east-west oriented line of storms that produced widespread wind damage in the northern part of Otsego county. No severe weather was reported from this storm when it evolved from the line, though radar shows a threat existed during this time. The KBGM and KENX radars suggests the tornado threat was low from this storm due to a lack of organized rotation. KENX reflectivities are relatively high (60 dBZ, VIL 55 kg/m2) at 2002 UTC suggesting a severe hail threat early. Both radars show a broad area of 50-64 kt ground-relative winds in lower levels, suggesting a damaging wind threat. The base velocity data from KENX shows these winds well ahead of the higher reflectivities at 2002 UTC, suggesting an upshear tilted updraft undercut by outflow, and the storm may have been heavily influenced by its strong cold pool. The storm becomes difficult to track around 2038 UTC when it merges with other storms, and it enters the variable terrain on the western side of the Hudson River Valley.

The “southern” storm in Otsego County at the start of the simulation evolved from the tail end of a line segment that is first seen in the KBGM data at 1927 UTC. The storm exhibits bow echo characteristics from both KBGM and KENX prior to the wind damage reports. Both radars show widespread areas of 50-64 kt wind in lower levels though the KBGM radar shows 64+ kt velocities earlier than the KENX radar. The KENX perspective shows classic bow echo signatures with an elevated rear inflow jet and strong mid-altitude radial convergence at 2017 UTC. From the start of the simulation, the storm moves at 70 kts. The storm apparently produced widespread wind damage in Otsego County (report times appear off) in the BGM CWA including downed trees, power lines, transmission towers, and blocked roads with 1 fatality due to a large tree limb falling in Oneonta. The storm apparently produced a brief, weak tornado (F0 damage, report time appears off) in northeast Delaware County, though radar does not show well defined cyclonic rotation or a gate-to-gate signature in this area. The KENX radar briefly showed some high reflectivity (60 dBZ, 55 kg/m2 VIL) and updraft intensification at 2027 UTC, suggesting a brief severe hail threat. As the storm moved into the ALY CWA, it produced general wind damage before passing over the radar and entering the Hudson River Valley. While in the valley, the storm merged with the other convection, whereby it became difficult to isolate around 2053 UTC. From 2048 UTC onward, the storms in this area combine into a large line and are referred to as **Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)**.

Another area to monitor in the early part of the simulation is in the northeast part of the CWA (referred to in the storm tables below as **Saratoga-Washington County Storm (2012-2048)**). A storm with weak reflectivities develops minimal to moderate strength mesocyclone rotational velocities in western Washington County at 2022 UTC. No severe weather is reported with this storm, and it weakens when it moves into the mountains east of the Hudson River Valley.

Another area to monitor for severe weather in the early part of the simulation is very close to the radar in the central part of the CWA. A brief F1 tornado occurs in the Albany metro area at 2037 UTC. The tornado comes from a small line segment very close to the radar that has sampling limitations due to the radar cone of silence. A minimal to moderate strength mesocyclone develops a couple of volume scans before the tornado, though the development is easy to overlook with the large number of storms and the other areas to monitor. The radar does not show a well-defined gate-gate signature or a clear tornado-scale “second velocity peak” with this tornado despite the close range (perhaps at longer range this small mesocyclone may have shown up as a gate-gate signature). The tornado passed close to the surface observation which has the tornado in the remark and a measured wind gust of 71 kts from the northwest. The updraft intensifies as it moves east, and it merges with surrounding storms.

Numerous severe storms merge to form a solid line around 2048 UTC (referred to in the storm tables below as **Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)**). This line develops classic bow echo signatures, and it produces widespread wind damage in the CWA. Large areas of 64+ kt ground-relative velocity are measured by the radar in low-levels along with an elevated rear-inflow jet. While wind damage is prevalent along the line, the southern portion of the solid line contains a very strong updraft where reflectivities and VIL are maximized. Severe hail is an additional threat in the southern part of the line, though no severe hail is reported with the bow echo. There is no organized cyclonic rotation with the bow echo so the supercell tornado threat is low. The TDA does trigger twice on bad data in ground clutter and noisy data in an area of anticyclonic shear.

The final area to monitor is the storm just southwest of the bow echo. The storm quickly develops high reflectivities/VIL on radar at 2038 UTC in Greene County. The strongest hail signatures occur as the storm moves into Columbia County. At times the hail algorithm predicts maximum sizes to be 3.75”, though the largest size hail reported was golf ball. No reports were within the low-level reflectivity maximum, so the hail sizes may have been larger in some areas. One wind damage report exists around the time of the most intense updraft signatures, though base velocities did not show a large area of strong low-level winds until later in the storm's life. Though the storm contained strong updraft signatures, the radar did not detect organized rotation, suggesting the tornado threat is low with this storm. The base velocity data in low-levels shows that the storm is riding along and behind the damaging wind-producing boundary being laid out by the bow echo. The positioning of the isolated storm's gust front out ahead of the radar echo along with the lack of organized persistent inflow, suggests the storm may have been adversely affected by this boundary.

Saratoga-Washington-Rensselaer-Bennington-Windham County Storm Cluster

Time (UTC)	Description
2002 KENX	70 kg/m2 VIL, 60dBZ to 31Kft, 70dBZ at 0.5 degrees, 1.75" MEHS, large area of 50-64 kt winds at 4500 ft AGL on south flank of storms, two distinct storm tops, storm located in the valley where channeling of wind may occur (Saratoga County)
2012 KENX	strong rotation (45 kt V_r) above 5Kft rapidly develops, large area of 64+ kt ground-relative winds at 5Kft in mesocyclone (Saratoga County)
2015	LSR ALY#8: 1" hail Milton Center (Saratoga County)
2016	LSR ALY#9: G52 Mechanicville (Saratoga County)
2017 KENX	rotation continues to intensify (V_r nearly 50kts), coverage of 64+kt velocities increase and is coincident with higher reflectivities (Saratoga County)
2020	LSR ALY#10: 1.75" hail Saratoga Springs, note: radar data doesn't match time of report (Saratoga County)
2022 KENX	2022 strong and deep TVS with 105 kt LLDV (TVS persists through 2038)
2022	LSR ALY#11: F3 tornado 0.7 NNE Ushers to 1 NNE Mechanicville, tornado damage through 2027 (Saratoga County)
2027 KENX	precipitation from line is seeding the parent storm marking the early stage of transition to HP supercell characteristics (Washington-Rensselaer Counties)
2027	LSR ALY#12: F2 tornado 1.9 NNW Reynolds to 2.6 ENE Walloomsac, tornado damage through 2045 (Rensselaer County)

Time (UTC)	Description
2030	LSR ALY#14: thunderstorm wind damage in Cambridge (Washington County)
2032	LSR ALY#16: thunderstorm wind damage in Arlington, note radar data does not match time of report (Bennington County)
2033 KENX	reflectivity aloft increases (55dBZ to 33 Kft) (Washington-Rensselaer Counties)
2035	LSR ALY#18: 0.75” hail Ballston Spa, note: radar data doesn’t match time of report (Saratoga County)
2038 KENX	HP supercell characteristics, updraft (Washington-Rensselaer Counties)
2043 KENX	De-aliasing failure above 1.5 degrees
2045	LSR ALY#22: F2 tornado crosses county line 1.7 WNW North Bennington to 2 ESE South Shaftsbury, tornado damage through 2055 (Bennington County)
2048 KENX	reflectivity aloft weakens significantly, VIL drops to 40 kg/m2
2058 KENX	weak TVS algorithm detection with poor time and height continuity in the base data

Considerations

- Does the trainee recognize that this storm has the highest threat of severe weather at the start of the simulation?
- Does the trainee recognize the initial large hail threat and multi-cell characteristics of this storm?
- Does the trainee recognize the rapid development of strong rotation in the 2012 UTC volume scan?
- Is a tornado warning issued before the TVS algorithm detects the tornado at 2022 UTC?
- Is the threat for large hail and strong winds included with tornado threat in the warning products?
- Is specific information about the location and movement of the tornado included in the warning products?
- Does the trainee recognize the shift to HP supercell characteristics, and do the warning products contain any information about the likelihood of the tornado being embedded in heavy precipitation?

- Does the trainee recognize the longer term trend of the storm moving into more stable air and higher terrain?

Otsego-Schoharie County “Northern” Storm 1947-2038)

Time (UTC)	Description
1930	LSR BGM#1: widespread wind damage in northern Otsego County from other storms in the line (through 1940); Trees and wires were blown down in Cooperstown and northern Burlington Flats between 3:30 and 3:40 EDT. Several roads were blocked due to the downed trees and wires. People were trapped in their vehicles by falling trees and some sustained injury from flying debris, broken glass, or falling wires. (Otsego County)
1958 KBGM	broad region of 50-64 kt base velocity at 5-6 Kft
2002 KENX	55 dBZ to 32 kft, MEHS 1.5”, 55 kg/m2 VIL, small areas of 50-64 kt ground-relative velocity at 2.4 Kft, 0.5 degree base velocity indicates storm undercut by outflow with gust front far ahead of main echo, storm located over the mountains
2007 KENX	reflectivities aloft weaken significantly, VIL decrease to 40 kg/m2
2038 KENX	radar echo difficult to isolate

Considerations

- Does the trainee consider sampling the storm from the BGM radar to get another perspective?
- Does the trainee recognize the rapid collapse of the storm that begins ~ 2007 UTC?
- Does the trainee recognize the primary threat shifts quickly from large hail to more damaging winds as the storm collapses?

Otsego-Schoharie-Albany County “Southern” Storm (1927-2053)

Time (UTC)	Description
2002 KENX	large area of 50-64 kt ground-relative velocity at 4.5 Kft, storm located over the mountains
2007 KENX	STI product shows 70+ kt storm motion for cell E0 (through 2022)
2013 KBGM	significant area of 64+ kt ground relative wind at 3.7 Kft (0.5 degree V)

Time (UTC)	Description
2017 KENX	line segment consolidating with elevated rear-inflow jet signature ~ 10Kft (2.4 degree SRM) and strong mid-altitude radial convergence, manual storm motion of 70 kts
2023 KBGM	areal increase of 64+ kt base velocity at 0.5 degrees
2027 KENX	60 dBZ to 30 Kft, VIL increases to 55 kg/m2, 1.75” MEHS, cell id changes which corrupts storm motion in STI product
2030	LSR ALY#13: thunderstorm wind damage in North Blenheim (Schoharie County)
2030	LSR BGM#5: thunderstorm wind damage in eastern Otsego County (through 2050), note time does not match the radar data; Trees and wires were blown down in Cooperstown and Laurens between 4:30 and 4:35 PM EDT. Numerous trees and wires were also downed by the wind in Schenevus at 4:45 pm and Oneonta at 4:50 pm EDT. Transmission towers and large signs were also toppled in Oneonta. Numerous roads were blocked due to the downed trees and many of them were closed for several hours. In Oneonta, a 32 year-old man was struck and killed by a large tree limb. Several additional injuries were sustained from flying debris.(Otsego County)
2032	LSR ALY#15: thunderstorm wind damage in Middleburgh (Schoharie County)
2033 KENX	50 kg/m2 VIL on second updraft core on tail end of storm
2043 KENX	64+ kt base velocity very close to the radar
2045	LSR BGM#8: F0 tornado Davenport to Fergusonville (note times do not match radar data); The tornado cut a discontinuous 3 mile path from Davenport Township northeastward through Butts Corners to Fergusonville between 4:45 and 4:55 EDT. The twister appeared to skip across mainly hilltop sections. large trees were twisted and snapped off on ridge tops with tree damage mainly confined to canopy level at somewhat lower elevations. In Butts Corners, several homes near the path of the tornado sustained siding and roof damage. The tornado appeared to lift back into the cloud base just north of Route 9 in Fergusonville. (Delaware County)
2053 KENX	radar echo difficult to isolate

Considerations

- Does the trainee recognize the Otsego County storm warrants interrogation before it enters the CWA?
- Does the trainee consider using the KBGM radar to interrogate the storm?
- Does the trainee recognize the persistent fast storm motions of 70 knots early in the radar data?
- Does the trainee utilize this quantitative information appropriately in the warning (correct storm motion and stronger or more detailed wording of damaging wind threat)?
- Does the trainee recognize the strong updraft signatures in the KENX data at 2027 UTC, and that the severe hail threat briefly increases as well?
- Does the trainee recognize the detection of strong winds over the radar?

Saratoga-Washington County Storm 2012-2048)

Time (UTC)	Description
2022 KENX	minimal-moderate rotation (V_r 30 kts) in western Washington County
2002 KENX	weak 40 kt delta V at 1.5 degree SRM

Considerations

- Does the trainee recognize this storm has developed rotation though the reflectivity structure is not impressive?

Schoharie-Schenectady-Albany County Line (2007-2048)

Time (UTC)	Description
2010	LSR ALY#7: thunderstorm wind damage in Schoharie, note: base velocity data correlates better with a storm to the west at ~ 2025 UTC.
2027 KENX	minimal mesocyclone best defined below 7Kft
2033 KENX	moderate mesocyclone (V_r 35 kts) above 11 Kft
2037	LSR ALY#19: F1 tornado 1.7 NNW Colony to 0.7 WNW Latham (through 2041 UTC) (Albany County)

Time (UTC)	Description
2040	LSR ALY#21: G71 Albany Airport (Albany County)
2043 KENX	55 dBZ to 30 Kft, 60 kg/m2 VIL

Considerations

- Does the trainee recognize the line of storms over the radar is being poorly sampled by the radar due to the cone of silence?
- Does the trainee recognize the minimal to moderate strength mesocyclone?
- Although the tornado is not well defined in the radar data due to a lack of a strong shear signature, does the trainee still consider the report as being potentially credible in association with the mesocyclone?

Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)

Time (UTC)	Description
2048 KENX	larger area of 64+ kt base velocities at 2Kft AGL as storms begin to merge into a line (high base velocity measurements become persistent in lower levels)
2050	LSR ALY#23: thunderstorm wind damage in Colonie (Albany County)
2050	LSR ALY#24: thunderstorm wind damage in Rotterdam (Schenectady County)
2050	LSR ALY#25: thunderstorm wind damage in Schenectady (Schenectady County)
2058 KENX	large area of 60 dBZ at 30 Kft at the top of the cone of silence, 60 kg/m2 VIL,1.75-2“ MEHS (through 2114), elevated rear-inflow jet becomes better visible at 9 Kft in 4panel Z/SRM as storm moves east of radar
2100	LSR ALY#27: thunderstorm wind damage in Brunswick (Rensselaer County)
2103 KENX	55 dBZ to 35 Kft, large area of 65 kg/m2 VIL
2105	LSR ALY#28: thunderstorm wind damage in East Greenbush (Rensselaer County)

Time (UTC)	Description
2105	LSR ALY#29: thunderstorm wind damage in Bennington (Bennington County)
2108 KENX	TVS algorithm triggers off of de-aliasing failure in ground clutter on elevated terrain
2110	LSR ALY#30: thunderstorm wind damage in Kinderhook (Columbia County)
2110	LSR ALY#31: thunderstorm wind damage in Stuyvesant (Columbia County)
2114 KENX	elevated rear inflow jet visible at 6 Kft (1.5 degree V) as line structure becomes highly linear, structure is persistent, 55 dBZ to 40 Kft, 70+ kg/m2 VIL, line motion is east at 55 kts
2120	LSR ALY#32: thunderstorm wind damage in Chatham (Columbia County)
2129 KENX	60 dBZ to 32 Kft
2135	LSR ALY#35: thunderstorm wind damage in Nassau, note: radar data doesn't match time of report (Rensselaer County)
2139 KENX	weak TVS algorithm detection in area of noisy velocity data with no temporal or height continuity; primary velocity pattern in area is anticyclonic shear
2142	LSR ALY#36: thunderstorm wind damage in Brattleboro (Windham County)
2149 KENX	reflectivity structure and VIL (35 kg/m2) weaken
2154 KENX	Primary updraft in line weakens significantly

Considerations

- Does the trainee recognize the widespread velocities of 64+ knots in lower levels as the storms begin to merge?
- Does the trainee recognize the elevated reflectivity cores with the stronger updraft areas in the line, indicating a higher probability of severe hail?
- Does the trainee recognize the mature bow-echo characteristics as the line of storms becomes more linear?
- Does the trainee recognize the ground clutter contaminating the velocity estimates at 0.5 degrees?

- If the trainee observes the TVS algorithm detection at 2108, does the trainee put less significance to the detection because of the velocity de-aliasing failure in the ground clutter?
- If the trainee observes the 2139 TVS algorithm detection, does the trainee put less significance to the detection because of the noisy data, the lack of temporal and height continuity, and the general velocity pattern being one of anticyclonic shear?

Greene-Albany-Columbia-Berkshire-Hampshire-Franklin County Storm

Time (UTC)	Description
2038 KENX	65 dBZ at 18Kft, 55 kg/m2 VIL, 2” MEHS (1.75+ estimates through 2149)
2043 KENX	70 dBZ at 18Kft
2048 KENX	VIL weakens to 40 kg/m2
2100	LSR ALY#26: 1” hail in Greeneville (Greene County)
2108 KENX	65 dBZ at 0.5 degrees
2114 KENX	large area of 55 kg/m2 VIL intensifies
2119 KENX	70 dBZ to 27 Kft, 60 dBZ to 32 Kft entering the radar cone of silence, 65 kg/m2 VIL, 3.75” MEHS (2.5”+ through 2139)
2124 KENX	70+ kg/m2 VIL
2126	LSR ALY#33: thunderstorm wind damage in Niverville (Columbia County)
2129 KENX	large area of 65 dBZ in the lowest three radar tilts (< 8Kft), three-body scatter spike at 1.5 degrees
2131	LSR ALY#34: 1” hail in Stuyvesant, note: time does not match radar data (Columbia County)
2134 KENX	larger area of 50-64 kt base velocity
2144 KENX	64+ kt base velocities at 3 Kft
2145	LSR ALY#37: 1.75” hail in Pittsfield (Berkshire County)
2154 KENX	1.8-2” OHP estimates with orientation of line becoming more parallel to storm motion
2200 KENX	VIL weakens to 40 kg/m2

Considerations

- Does the trainee recognize the early threat for severe hail by diagnosing elevated reflectivity cores?
- Does the trainee use enhanced wording in the warning products to describe the hail threat with the persistent severe hail signatures in the base data?
- Does the trainee use the Hail Index algorithm output in estimating hail size in the warnings, or are sizes estimated based on analysis of base data along with storm reports?
- Does the trainee recognize the boundary being laid out by the bow echo that is intersecting the storm?
- Does the trainee recognize the base velocity data shows the strong boundary has surged out ahead of the storm?
- Does the trainee recognize the storm is having a difficult time developing organized, strong inflow, and that the velocity data suggests the storm updraft has been “undercut” by outflow?
- Does the trainee recognize the lack of organized rotation throughout the storm’s life decreases the tornado threat?
- Does the trainee recognize the appearance of higher base velocities around 2134-2144?
- Does the trainee recognize the probability of severe winds increases with the detection of 50 and 64 kt winds in lower levels?
- Does the trainee occasionally monitor the radar precipitation estimates even though it is not the primary severe weather threat?
- Does the trainee recognize the flash flooding threat increases as the line becomes more east-west oriented, parallel to storm motion?
- Does the trainee consider that the precipitation is likely overestimated in areas where hail signatures exist?

5: Virtual Reality Simulation (Severe Threat)

I. Introduction

This simulation focuses on the unique aspects of handling severe thunderstorm warning responsibility for a CWA containing numerous storms. The heavy workload and complicated line segment geometry make this event a good opportunity to sectorize by severe weather type (severe versus tornado) rather than by geography. This simulation is appropriate for an experienced warning forecaster who is proficient with the mechanics of issuing warnings and can benefit from practicing warning workload management.

Objective

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Trainer Evaluation Guide), and V (Post-simulation Briefing) have been designed for a two-person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Interrogate the severe threat for the entire CWA, and issue severe thunderstorm warnings and follow up statements.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and document trainee briefing, and discuss sectorizing issues for this event.

Simulation: Manage the simulation, evaluate the performance of the trainee, and interject information such as spotter reports, special forecast requests, and any type of challenges that can happen in a real event (be creative!).

Post-Brief: Discuss trainee performance and any lessons learned from the simulation and how they can be implemented at the local office.

This virtual reality simulation is designed to take 3 hours to complete, with 30 minutes for the pre-simulation briefing, 2 hours for the simulation, and 30 minutes for the post-brief. The simulation starts at 2005 UTC on May 31st, 1998 and ends at 2205 UTC on May 31st, 1998. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sector issues.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 2005 UTC on May 31st, 1998 to 2205 UTC on May 31st, 1998.

4. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

5. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the ALY CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

6. Instruct the trainee to:

- Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA.
- Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.
- Evaluate warning sectorization challenges.

7. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

- 0-6 km shear 50 kts and BRN shear > 40 is supportive of supercell storms.
- Anvil-level SR flow (40 kts) suggests wet-end of classic supercells given isolated initiation.
- Low-level (0-3 km) shear is very strong (40 kts), higher just north of outflow boundary, enhancing supercell tornado potential.
- Midlevel SR flow for right-moving supercells is 20 kts which is favorable for tornadoes.
- Morning soundings indicates a layer of dry air and steep lapse rates suggestive of an Elevated Mixed Layer (EML) at Pittsburgh. The Albany sounding shows elevated moisture surging over a warm frontal boundary.
- Surface dewpoint depressions 15° F or less allow for favorably low LCLs for tornadoes assuming surface dewpoints are well mixed in the boundary layer.
- Midlevel lapse rates are not indicated to be steep and the lack of analyzed midlevel dry air results in theta-E differences < 30° K from the surface to 600 mb. Wet microburst potential is generally low. However, highest potential would be in southern zones with access to dry midlevel air with steep lapse rates evident in the PBZ 12 UTC Skew-T.

- Large hail potential is significant given 20 kt storm-relative midlevel flow, strong shear and high CAPEs. Wet Bulb Zero (WBZ) values (~10.5-11 kft MSL) just above the optimal layer for greatest severe hail threat. Therefore, large hail potential is greatest for supercell storms, and limited for nonsupercells.
- Short-duration, heavy rain potential heightened due to storms realizing the high CAPE, and deep moisture. Rapid storm motion will minimize prolonged heavy rainfall. “Corfidi” vector motion is low suggesting that if a MCC does form, prolonged heavy rain potential is possible.
- In addition, high midlevel lapse rates are likely residing in the southern half of the CWA. LAPS is not depicting these lapse rates.

8. Discuss the warning sector issues, and have the trainee sectorize by severe weather type (severe) for this scenario. The trainee will be responsible for evaluating the severe threat (hail, wind, and flooding) for the whole CWA.The trainer will inform the trainee when a tornado warning is going to be issued. As long as the tornado warning is in effect, the trainee will not issue severe thunderstorm warnings for that storm, though they should still interrogate the severe thunderstorm threat for all storms.

9. Make sure the trainee is comparing direct observations with any LAPS, or other diagnostic model output.

10. Inform the trainee that the flash flood guidance for the ALY CWA is approximately 2” for one hour, and 3” for three hours.

11. Point out on the SPC products provided in Appendix B that the CWA is in a high risk area, and a tornado watch has been issued with a threat for tornadoes, hail to 2 inches in diameter, and wind gusts to 70 kts.

III. Simulation

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. This 2 hour simulation starts at 2005 UTC on May 31st, 1998, and ends at 2205 UTC on May 31st, 1998. For a storm-by-storm breakdown of important features (both severe and tornado) in the data and important evaluation points (both severe and tornado), consult the Trainer Evaluation Guide on page 5-8.

Trainer Tasks

1. State to the trainee:

- The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products.
- The trainee will be responsible for interrogating the severe thunderstorm threat (CWA wide) and creating severe thunderstorm warnings and follow on statements. This is another way to sectorize in order to better distribute workload. This may be particularly useful when sectorizing by geography or by storms is not manageable. The trainee is to assume the tornado threat is being covered by someone else. When a storm's threat is transitioning from severe to tornado, the trainer, acting as a 2nd warning forecaster with the tornado threat, will inform the trainee. At that point the trainee will not create warnings for that storm, though they should still monitor the severe thunderstorm threat if they have time.
- There will be no pauses during the 2 hour simulation (plan accordingly).
- The trainee should communicate any sectorizing issues/confusion with the trainer during the event.
- The trainer will be forwarding spotter reports to the trainee during the simulation.

2. Close down any existing D2D sessions, and start the simulation for the time period 2005 UTC on May 31st, 1998 to 2205 UTC on May 31st, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

3. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under "File", "Export to File...".
- Type in the name of the warning at the end of the path in the "filename" box on the bottom of the popup window and click OK.

4. Give the trainee 5-10 minutes to set up their D2D sessions.

5. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide on page 5-8 (consult image in Appendix A for graphical locations), and make up conflicting spotter reports during the simulation to determine if the trainee is evaluating the reports well. Any other incoming calls or distractions should be interjected as to simulate a real environment. This could include briefings to EMS, toxic spills, failure for a warning to transmit, etc.

6. At 2017 UTC inform the trainee that the cluster of cells with strong rotation in southern Saratoga County is going to have a tornado warning issued. The trainee should provide the trainer with all hail, wind, and flooding threat information at this time that can be included in the tornado warning. Evaluate the trainee’s ability to clearly convey the severe thunderstorm threat information.

7. At 2037 UTC inform the trainee of that a tornado has been reported in northeast Albany County near Colony. The tornado warning forecaster is going to issue a tornado warning, and they would like to know the current state of severe weather threats with this storm. Evaluate the trainee’s ability to effectively answer this request in a timely manner.

8. At 2103 UTC consider giving a distracting request. Currently a manhunt is underway in northern Berkshire County. The center of operations is just south of the town of Adams. The head of operations would like to know a detailed threat of severe weather for the northern Berkshire County to aid keeping the search teams safe. Evaluate the trainee’s ability to convey all threats of severe weather in a timely manner.

9. At 2124 UTC consider giving a distracting request. The Berkshire County emergency manager in Pittsfield is on the phone. A TV station out of Albany is giving live coverage of the storm in Northern Columbia County, and they are saying the NEXRAD Doppler is showing 3.75” hail from this storm. He wants to know what size of hail to expect from this storm. Evaluate the trainee’s ability to effectively answer the request in a timely manner.

10. At 2140 UTC consider disrupting the warning operations. Simulate a D2D crash or spontaneous logout. ***Do not stop the simulator.*** Either have the trainee exit and restart D2D, or have the trainee stop using D2D temporarily and explain how they would recover. Evaluate the trainee’s ability to recover from the disruption.

11. At 2200 UTC consider giving a distracting request. The neighboring CWA to the east (BOX) is on the phone asking for some assistance. There is a congressional retreat going on in a lodge in western Franklin County that is in a flood prone area, and they have been asked to provide a detailed heavy rainfall forecast for the Shelburne Falls area. They are having serious AWIPS problems that have prevented them from being able to effectively evaluate the threat, and they would like the trainee’s thoughts on flooding for the Shelburne Falls area. Evaluate the trainee's ability to effectively answer the request in a timely manner.

12. At the end of the simulation, give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objective of the post simulation briefing is to summarize the successes and failures of the warning process and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation done during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- Handling stress and workload so as to keep the effective flow of information going.
- Off-loading tasks as necessary.
- Maintaining the big picture issues while periodically focussing on the details.
- Maintaining a high level of situation awareness throughout.
- Recognizing the development of bow echo structure before damaging wind at the ground occurs.
- Optimal usage of base data analysis with radar derived products and algorithms.
- Optimal sectorization.

Trainer Tasks

1. Ask the trainee to:

- Discuss challenges in managing the warning workload.
- Discuss any problems encountered with responding to the disruptions in the warning environment.

2. Review the reports and the times to compare to the warnings.

3. Discuss the lessons learned from the event, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. The evaluation of the trainee by the trainer is to be done while the trainee is actively involved in the warning operations. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation. Note this section contains information on both the severe and tornado threats for each storm. For this simulation the trainer should focus on the evaluation points relevant to the severe threat.

General Issues

Time (UTC)	Description
1801-0557 KBGM	radar data time period (limited radar products)
2002-0034 KENX	radar data time period (full set of radar products)
prior to 2053 KENX	OHP data not available (This is an artifact of the process of developing this case.)
2043 KENX	widespread dealiasing failures aloft

Considerations

- Does the trainee anticipate the general threat of severe weather to shift more to the south due to the initial storm geometry and the better instability over this area?
- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?

- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, and LAPS)?
- Does the trainee recognize the bands of weak reflectivity east of the radar are associated with the mountains, and that the velocity data is being contaminated in this area?
- Does the trainee recognize the cone of silence significantly affects the ability to determine many middle and upper-level storm characteristics for many of the important storms passing over the radar?

Storm Summary

During the simulation there are numerous areas requiring detailed monitoring for severe weather in the CWA. The first area to monitor includes a cluster of cells in the Hudson River Valley in Saratoga County (referenced in the cell table below as **"Saratoga-Washington-Rensselaer-Bennington-Windham County Storm Cluster"**). The initial radar signatures (radar data starts at 2002 UTC) suggest large hail and damaging winds are the primary threat with these cells. Hail up to golf ball size and wind gusts to 52 kts are reported first with the cell cluster. Radar reflectivities are high (70 dBZ, VIL 70+ kg/m2) and base velocities starting from 2007 UTC show a large area of 50-64 kt winds on the south side of the cell cluster that correlates well with the subsequent 52 kt damaging wind report and the eventual mesocyclone formation/intensification. General wind damage is also reported with the cell cluster as the primary threat shifts rapidly to tornado.

In the first few volume scans of the simulation the mesocyclone rapidly intensifies over Saratoga County with strong rotation above 5 Kft. No gate-to-gate signature precedes the tornado, and the first TDA detection occurs with the tornado at 2022 UTC. The storm produces tornadoes with generally F2 and some F3 damage nearly continuously from 2022 - 2055. Strong gate-gate shears exist through much of the tornadoes lifetimes, however there are a couple of volume scans near the end of the tornado damage where the radar observed shears are weak while the tornado is still doing significant damage. Early in the tornado development, one of the cells in the cluster intensifies to the southwest of the tornado, generating heavy rain near the tornado. The cluster of cells eventually transitions to an HP supercell structure with much of the heavy precipitation around the tornado and on the back side of the storm. The tornado damage reports end as the storm gradually weakens and moves east out of the valley into the higher terrain where the CAPE is analyzed to be less.

Another area with impending severe weather at the start of the simulation is located in the mountains just west of the CWA. Two storms (referenced below as **Otsego-Schoharie County "Northern" Storm (1947-2038)** and **Cortland-Chenango-Otsego-Schoharie-Albany County "Southern" Storm (1927-2053)**) move out of Otsego county in the BGM CWA where they produced severe weather. The "northern" storm in Otsego County at the start of the simulation evolved from an east-west oriented line of storms that produced widespread wind damage in the northern part of Otsego county. No severe weather was reported from this storm when it evolved from the line, though radar shows a threat existed during this time. The KBGM and KENX radars suggests the tornado threat was low from this storm due to a lack of organized rotation. KENX reflectivities are relatively high (60 dBZ, VIL 55 kg/m2) at 2002 UTC suggesting a severe hail threat early. Both radars show a broad area of 50-64 kt ground-relative winds in lower levels, suggesting a damaging wind threat. The base velocity data from KENX shows these winds well ahead of the higher reflectivities at 2002 UTC, suggesting an upshear tilted updraft undercut by outflow, and the storm may have been heavily influenced by its strong cold pool. The storm becomes difficult to track around 2038 UTC when it merges with other storms, and it enters the variable terrain on the western side of the Hudson River Valley.

The "southern" storm in Otsego County at the start of the simulation evolved from the tail end of a line segment that is first seen in the KBGM data at 1927 UTC. The storm exhibits bow echo characteristics from both KBGM and KENX prior to the wind damage reports. Both radars show widespread areas of 50-64 kt wind in lower levels though the KBGM radar shows 64+ kt velocities earlier than the KENX radar. The KENX perspective shows classic bow echo signatures with an elevated rear inflow jet and strong mid-altitude radial convergence at 2017 UTC. From the start of the simulation, the storm moves at 70 kts. The storm apparently produced widespread wind damage in Otsego County (report times appear off) in the BGM CWA including downed trees, power lines, transmission towers, and blocked roads with 1 fatality due to a large tree limb falling in Oneonta. The storm apparently produced a brief, weak tornado (F0 damage, report time appears off) in northeast Delaware County, though radar does not show well defined cyclonic rotation or a gate-to-gate signature in this area. The KENX radar briefly showed some high reflectivity (60 dBZ, 55 kg/m2 VIL) and updraft intensification at 2027 UTC, suggesting a brief severe hail threat. As the storm moved into the ALY CWA, it produced general wind damage before passing over the radar and entering the Hudson River Valley. While in the valley, the storm merged with the other convection, whereby it became difficult to isolate around 2053 UTC. From 2048 UTC onward, the storms in this area combine into a large line and are referred to as **Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)**.

Another area to monitor in the early part of the simulation is in the northeast part of the CWA (referred to in the storm tables below as **Saratoga-Washington County Storm (2012-2048)**). A storm with weak reflectivities develops minimal to moderate strength mesocyclone rotational velocities in western Washington County at 2022 UTC. No severe weather is reported with this storm, and it weakens when it moves into the mountains east of the Hudson River Valley.

Another area to monitor for severe weather in the early part of the simulation is very close to the radar in the central part of the CWA. A brief F1 tornado occurs in the Albany metro area at 2037 UTC. The tornado comes from a small line segment very close to the radar that has sampling limitations due to the radar cone of silence. A minimal to moderate strength mesocyclone develops a couple of volume scans before the tornado, though the development is easy to overlook with the large number of storms and the other areas to monitor. The radar does not show a well-defined gate-gate signature or a clear tornado-scale “second velocity peak” with this tornado despite the close range (perhaps at longer range this small mesocyclone may have shown up as a gate-gate signature). The tornado passed close to the surface observation which has the tornado in the remark and a measured wind gust of 71 kts from the northwest. The updraft intensifies as it moves east, and it merges with surrounding storms.

Numerous severe storms merge to form a solid line around 2048 UTC (referred to in the storm tables below as **Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)**). This line develops classic bow echo signatures, and it produces widespread wind damage in the CWA. Large areas of 64+ kt ground-relative velocity are measured by the radar in low-levels along with an elevated rear-inflow jet. While wind damage is prevalent along the line, the southern portion of the solid line contains a very strong updraft where reflectivities and VIL are maximized. Severe hail is an additional threat in the southern part of the line, though no severe hail is reported with the bow echo. There is no organized cyclonic rotation with the bow echo so the supercell tornado threat is low. The TDA does trigger twice on bad data in ground clutter and noisy data in an area of anticyclonic shear.

The final area to monitor is the storm just southwest of the bow echo. The storm quickly develops high reflectivities/VIL on radar at 2038 UTC in Greene County. The strongest hail signatures occur as the storm moves into Columbia County. At times the hail algorithm predicts maximum sizes to be 3.75”, though the largest size hail reported was golf ball. No reports were within the low-level reflectivity maximum, so the hail sizes may have been larger in some areas. One wind damage report exists around the time of the most intense updraft signatures, though base velocities did not show a large area of strong low-level winds until later in the storm’s life. Though the storm contained strong updraft signatures, the radar did not detect organized rotation, suggesting the tornado threat is low with this storm. The base velocity data in low-levels shows that the storm is riding along and behind the damaging wind-producing boundary being laid out by the bow echo. The positioning of the isolated storm’s gust front out ahead of the radar echo along with the lack of organized persistent inflow, suggests the storm may have been adversely affected by this boundary.

Saratoga-Washington-Rensselaer-Bennington-Windham County Storm Cluster

Time (UTC)	Description
2002 KENX	70 kg/m2 VIL, 60dBZ to 31Kft, 70dBZ at 0.5 degrees, 1.75” MEHS, large area of 50-64 kt winds at 4500 ft AGL on south flank of storms, two distinct storm tops, storm located in the valley where channeling of wind may occur (Saratoga County)
2012 KENX	strong rotation (45 kt V_r) above 5Kft rapidly develops, large area of 64+ kt ground-relative winds at 5Kft in mesocyclone (Saratoga County)
2015	LSR ALY#8: 1” hail Milton Center (Saratoga County)
2016	LSR ALY#9: G52 Mechanicville (Saratoga County)
2017 KENX	rotation continues to intensify (V_r nearly 50kts), coverage of 64+kt velocities increase and is coincident with higher reflectivities (Saratoga County)
2020	LSR ALY#10: 1.75” hail Saratoga Springs, note: radar data doesn’t match time of report (Saratoga County)

Time (UTC)	Description
2022 KENX	2022 strong and deep TVS with 105 kt LLDV (TVS persists through 2038)
2022	LSR ALY#11: F3 tornado 0.7 NNE Ushers to 1 NNE Mechanicville, tornado damage through 2027 (Saratoga County)
2027 KENX	precipitation from line is seeding the parent storm marking the early stage of transition to HP supercell characteristics (Washington-Rensselaer Counties)
2027	LSR ALY#12: F2 tornado 1.9 NNW Reynolds to 2.6 ENE Walloomsac, tornado damage through 2045 (Rensselaer County)
2030	LSR ALY#14: thunderstorm wind damage in Cambridge (Washington County)
2032	LSR ALY#16: thunderstorm wind damage in Arlington, note radar data does not match time of report (Bennington County)
2033 KENX	reflectivity aloft increases (55dBZ to 33 Kft) (Washington-Rensselaer Counties)
2035	LSR ALY#18: 0.75” hail Ballston Spa, note: radar data doesn’t match time of report (Saratoga County)
2038 KENX	HP supercell characteristics, updraft (Washington-Rensselaer Counties)
2043 KENX	De-aliasing failure above 1.5 degrees
2045	LSR ALY#22: F2 tornado crosses county line 1.7 WNW North Bennington to 2 ESE South Shaftsbury, tornado damage through 2055 (Bennington County)
2048 KENX	reflectivity aloft weakens significantly, VIL drops to 40 kg/m2
2058 KENX	weak TVS algorithm detection with poor time and height continuity in the base data

Considerations

- Does the trainee recognize that this storm has the highest threat of severe weather at the start of the simulation?
- Does the trainee recognize the initial large hail threat and multi-cell characteristics of this storm?
- Does the trainee recognize the rapid development of strong rotation in the 2012 UTC volume scan?

- Is a tornado warning issued before the TVS algorithm detects the tornado at 2022 UTC?
- Is the threat for large hail and strong winds included with tornado threat in the warning products?
- Is specific information about the location and movement of the tornado included in the warning products?
- Does the trainee recognize the shift to HP supercell characteristics, and do the warning products contain any information about the likelihood of the tornado being embedded in heavy precipitation?
- Does the trainee recognize the longer term trend of the storm moving into more stable air and higher terrain?

Otsego-Schoharie County “Northern” Storm 1947-2038)

Time (UTC)	Description
1930	LSR BGM#1: widespread wind damage in northern Otsego County from other storms in the line (through 1940); Trees and wires were blown down in Cooperstown and northern Burlington Flats between 3:30 and 3:40 EDT. Several roads were blocked due to the downed trees and wires. People were trapped in their vehicles by falling trees and some sustained injury from flying debris, broken glass, or falling wires. (Otsego County)
1958 KBGM	broad region of 50-64 kt base velocity at 5-6 Kft
2002 KENX	55 dBZ to 32 kft, MEHS 1.5”, 55 kg/m2 VIL, small areas of 50-64 kt ground-relative velocity at 2.4 Kft, 0.5 degree base velocity indicates storm undercut by outflow with gust front far ahead of main echo, storm located over the mountains
2007 KENX	reflectivities aloft weaken significantly, VIL decrease to 40 kg/m2
2038 KENX	radar echo difficult to isolate

Considerations

- Does the trainee consider sampling the storm from the BGM radar to get another perspective?
- Does the trainee recognize the rapid collapse of the storm that begins ~ 2007 UTC?
- Does the trainee recognize the primary threat shifts quickly from large hail to more damaging winds as the storm collapses?

Otsego-Schoharie-Albany County “Southern” Storm (1927-2053)

Time (UTC)	Description
2002 KENX	large area of 50-64 kt ground-relative velocity at 4.5 Kft, storm located over the mountains
2007 KENX	STI product shows 70+ kt storm motion for cell E0 (through 2022)
2013 KBGM	significant area of 64+ kt ground relative wind at 3.7 Kft (0.5 degree V)
2017 KENX	line segment consolidating with elevated rear-inflow jet signature ~ 10Kft (2.4 degree SRM) and strong mid-altitude radial convergence, manual storm motion of 70 kts
2023 KBGM	areal increase of 64+ kt base velocity at 0.5 degrees
2027 KENX	60 dBZ to 30 Kft, VIL increases to 55 kg/m2, 1.75” MEHS, cell id changes which corrupts storm motion in STI product
2030	LSR ALY#13: thunderstorm wind damage in North Blenheim (Schoharie County)
2030	LSR BGM#5: thunderstorm wind damage in eastern Otsego County (through 2050), note time does not match the radar data; Trees and wires were blown down in Cooperstown and Laurens between 4:30 and 4:35 PM EDT. Numerous trees and wires were also downed by the wind in Schenevus at 4:45 pm and Oneonta at 4:50 pm EDT. Transmission towers and large signs were also toppled in Oneonta. Numerous roads were blocked due to the downed trees and many of them were closed for several hours. In Oneonta, a 32 year-old man was struck and killed by a large tree limb. Several additional injuries were sustained from flying debris.(Otsego County)
2032	LSR ALY#15: thunderstorm wind damage in Middleburgh (Schoharie County)
2033 KENX	50 kg/m2 VIL on second updraft core on tail end of storm
2043 KENX	64+ kt base velocity very close to the radar

Time (UTC)	Description
2045	LSR BGM#8: F0 tornado Davenport to Fergusonville (note times do not match radar data); The tornado cut a discontinuous 3 mile path from Davenport Township northeastward through Butts Corners to Fergusonville between 4:45 and 4:55 EDT. The twister appeared to skip across mainly hilltop sections. large trees were twisted and snapped off on ridge tops with tree damage mainly confined to canopy level at somewhat lower elevations. In Butts Corners, several homes near the path of the tornado sustained siding and roof damage. The tornado appeared to lift back into the cloud base just north of Route 9 in Fergusonville. (Delaware County)
2053 KENX	radar echo difficult to isolate

Considerations

- Does the trainee recognize the Otsego County storm warrants interrogation before it enters the CWA?
- Does the trainee consider using the KBGM radar to interrogate the storm?
- Does the trainee recognize the persistent fast storm motions of 70 knots early in the radar data?
- Does the trainee utilize this quantitative information appropriately in the warning (correct storm motion and stronger or more detailed wording of damaging wind threat)?
- Does the trainee recognize the strong updraft signatures in the KENX data at 2027 UTC, and that the severe hail threat briefly increases as well?
- Does the trainee recognize the detection of strong winds over the radar?

Saratoga-Washington County Storm 2012-2048)

Time (UTC)	Description
2022 KENX	minimal-moderate rotation (V_r 30 kts) in western Washington County
2002 KENX	weak 40 kt delta V at 1.5 degree SRM

Considerations

- Does the trainee recognize this storm has developed rotation though the reflectivity structure is not impressive?

Schoharie-Schenectady-Albany County Line (2007-2048)

Time (UTC)	Description
2010	LSR ALY#7: thunderstorm wind damage in Schoharie, note: base velocity data correlates better with a storm to the west at ~ 2025 UTC.
2027 KENX	minimal mesocyclone best defined below 7Kft
2033 KENX	moderate mesocyclone (V_r 35 kts) above 11 Kft
2037	LSR ALY#19: F1 tornado 1.7 NNW Colony to 0.7 WNW Latham (through 2041 UTC) (Albany County)
2040	LSR ALY#21: G71 Albany Airport (Albany County)
2043 KENX	55 dBZ to 30 Kft, 60 kg/m2 VIL

Considerations

- Does the trainee recognize the line of storms over the radar is being poorly sampled by the radar due to the cone of silence?
- Does the trainee recognize the minimal to moderate strength mesocyclone?
- Although the tornado is not well defined in the radar data due to a lack of a strong shear signature, does the trainee still consider the report as being potentially credible in association with the mesocyclone?

Albany-Rensselaer-Columbia-Bennington-Berkshire-Windham-Franklin County Line (2048-2225)

Time (UTC)	Description
2048 KENX	larger area of 64+ kt base velocities at 2Kft AGL as storms begin to merge into a line (high base velocity measurements become persistent in lower levels)
2050	LSR ALY#23: thunderstorm wind damage in Colonie (Albany County)

Time (UTC)	Description
2050	LSR ALY#24: thunderstorm wind damage in Rotterdam (Schenectady County)
2050	LSR ALY#25: thunderstorm wind damage in Schenectady (Schenectady County)
2058 KENX	large area of 60 dBZ at 30 Kft at the top of the cone of silence, 60 kg/m2 VIL,1.75-2“ MEHS (through 2114), elevated rear-inflow jet becomes better visible at 9 Kft in 4panel Z/SRM as storm moves east of radar
2100	LSR ALY#27: thunderstorm wind damage in Brunswick (Rensselaer County)
2103 KENX	55 dBZ to 35 Kft, large area of 65 kg/m2 VIL
2105	LSR ALY#28: thunderstorm wind damage in East Greenbush (Rensselaer County)
2105	LSR ALY#29: thunderstorm wind damage in Bennington (Bennington County)
2108 KENX	TVS algorithm triggers off of de-aliasing failure in ground clutter on elevated terrain
2110	LSR ALY#30: thunderstorm wind damage in Kinderhook (Columbia County)
2110	LSR ALY#31: thunderstorm wind damage in Stuyvesant (Columbia County)
2114 KENX	elevated rear inflow jet visible at 6 Kft (1.5 degree V) as line structure becomes highly linear, structure is persistent, 55 dBZ to 40 Kft, 70+ kg/m2 VIL, line motion is east at 55 kts
2120	LSR ALY#32: thunderstorm wind damage in Chatham (Columbia County)
2129 KENX	60 dBZ to 32 Kft
2135	LSR ALY#35: thunderstorm wind damage in Nassau, note: radar data doesn’t match time of report (Rensselaer County)
2139 KENX	weak TVS algorithm detection in area of noisy velocity data with no temporal or height continuity; primary velocity pattern in area is anticyclonic shear
2142	LSR ALY#36: thunderstorm wind damage in Brattleboro (Windham County)
2149 KENX	reflectivity structure and VIL (35 kg/m2) weaken

Time (UTC)	Description
2154 KENX	Primary updraft in line weakens significantly

Considerations

- Does the trainee recognize the widespread velocities of 64+ knots in lower levels as the storms begin to merge?
- Does the trainee recognize the elevated reflectivity cores with the stronger updraft areas in the line, indicating a higher probability of severe hail?
- Does the trainee recognize the mature bow-echo characteristics as the line of storms becomes more linear?
- Does the trainee recognize the ground clutter contaminating the velocity estimates at 0.5 degrees?
- If the trainee observes the TVS algorithm detection at 2108, does the trainee put less significance to the detection because of the velocity de-aliasing failure in the ground clutter?
- If the trainee observes the 2139 TVS algorithm detection, does the trainee put less significance to the detection because of the noisy data, the lack of temporal and height continuity, and the general velocity pattern being one of anticyclonic shear?

Greene-Albany-Columbia-Berkshire-Hampshire-Franklin County Storm

Time (UTC)	Description
2038 KENX	65 dBZ at 18Kft, 55 kg/m2 VIL, 2” MEHS (1.75+ estimates through 2149)
2043 KENX	70 dBZ at 18Kft
2048 KENX	VIL weakens to 40 kg/m2
2100	LSR ALY#26: 1” hail in Greeneville (Greene County)
2108 KENX	65 dBZ at 0.5 degrees
2114 KENX	large area of 55 kg/m2 VIL intensifies
2119 KENX	70 dBZ to 27 Kft, 60 dBZ to 32 Kft entering the radar cone of silence, 65 kg/m2 VIL, 3.75” MEHS (2.5”+ through 2139)
2124 KENX	70+ kg/m2 VIL

Time (UTC)	Description
2126	LSR ALY#33: thunderstorm wind damage in Niverville (Columbia County)
2129 KENX	large area of 65 dBZ in the lowest three radar tilts (< 8Kft), three-body scatter spike at 1.5 degrees
2131	LSR ALY#34: 1” hail in Stuyvesant, note: time does not match radar data (Columbia County)
2134 KENX	larger area of 50-64 kt base velocity
2144 KENX	64+ kt base velocities at 3 Kft
2145	LSR ALY#37: 1.75” hail in Pittsfield (Berkshire County)
2154 KENX	1.8-2” OHP estimates with orientation of line becoming more parallel to storm motion
2200 KENX	VIL weakens to 40 kg/m2

Considerations

- Does the trainee recognize the early threat for severe hail by diagnosing elevated reflectivity cores?
- Does the trainee use enhanced wording in the warning products to describe the hail threat with the persistent severe hail signatures in the base data?
- Does the trainee use the Hail Index algorithm output in estimating hail size in the warnings, or are sizes estimated based on analysis of base data along with storm reports?
- Does the trainee recognize the boundary being laid out by the bow echo that is intersecting the storm?
- Does the trainee recognize the base velocity data shows the strong boundary has surged out ahead of the storm?
- Does the trainee recognize the storm is having a difficult time developing organized, strong inflow, and that the velocity data suggests the storm updraft has been “undercut” by outflow?
- Does the trainee recognize the lack of organized rotation throughout the storm’s life decreases the tornado threat?
- Does the trainee recognize the appearance of higher base velocities around 2134-2144?

- Does the trainee recognize the probability of severe winds increases with the detection of 50 and 64 kt winds in lower levels?
- Does the trainee occasionally monitor the radar precipitation estimates even though it is not the primary severe weather threat?
- Does the trainee recognize the flash flooding threat increases as the line becomes more east-west oriented, parallel to storm motion?
- Does the trainee consider that the precipitation is likely overestimated in areas where hail signatures exist?

6: Real Time Simulation

I. Introduction

This real-time simulation example focuses on the southern part of the CWA containing two storms, one which maintains a steady state character, and another tornadic supercell approaching the CWA from the west. The simple signatures and manageable workload with these storms allows the trainee time to focus on using WarnGen and developing timing skills. This simulation is appropriate for a novice warning forecaster who has been exposed to using WarnGen and can benefit from focusing primarily on the mechanics of issuing warnings.

Objectives

The training objectives of this real-time simulation are to demonstrate:

- Ability to effectively use WarnGen to create warnings.
- Ability to effectively use WarnGen to issue severe weather statements as a follow up warning product.
- A timely routine for calling up products to evaluate the threat for tornadoes, hail, wind, and flooding.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Post-simulation Briefing), and V (Trainer Evaluation Guide), have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Obtain a summary shift change briefing by the trainer.

Simulation: Issue warnings and follow up statements for the sector shown in Figure C-2 on page C-3. Specifically, practice on an isolated storm starting in Southwest Ulster County through Central Berkshire County, and then the tornadic supercell approaching Western Ulster County.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation and give a shift change briefing summarizing the threat for all severe weather types (tornado, hail, wind, flooding).

Simulation: Manage the simulation, evaluate the performance of the trainee, and interject spotter reports.

Post-Brief: Discuss trainee performance, any lessons learned from the simulation, and how they can be implemented at the local office.

This real-time simulation is designed to take 2.75 hours to complete, with 15 minutes for the pre-simulation briefing, 2 hours for the simulation, and 30 minutes for the post-brief. As with all simulation examples, times can be adjusted as needed. The simulation starts at 2200 UTC on May 31st, 1998 and ends at 0000 UTC on June 1st, 1998. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainer to briefly describe the threat for severe weather (tornado, hail, wind, and flash flooding) to the trainee. The trainer should step through the following tasks to prepare the simulation.

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-C-2 on page C-3) for discussing warning sector issues.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 2200 UTC on May 31st, 1998 to 0000 UTC on June 1st, 1998.

4. Stop the simulator immediately to allow the trainer to brief the trainee on the environment up to the start time.

5. Start a D2D session, and if the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures, or the trainer may wish to build them for the trainee.

6. Provide a pre-simulation briefing for the trainee. Some elements that may be used include:

- Load a 0.5° Z/SRM from the KALY radar and overlay the CWA map to familiarize the trainee with the geography, and inform trainee they will be responsible for warning for two storms south and southwest of the radar.
- Point out on the SPC products provided in Appendix B that the warning sector is in a high risk area, with a threat for tornadoes, hail to 2 inch diameter, and wind gusts to 70 kts.
- Point out the isolated storm beginning in Sullivan County. Then point out the tornadic supercell in Western Delaware County, just east of Binghamton. Note that warnings can only be issued within the CWA boundary.
- Load ETA 4 panel family on regional scale and show the ETA is developing storms over all of the CWA from 18-00 UTC.
- On a clear state scale load surface obs, then vis satellite, then LAPS CAPE and CIN (four product overlay) to point out the reduction in instability north of an east-west outflow boundary as convection swept through the northern CWA. The two storms of interest still have an untouched unstable airmass.
- Load a LAPS 0-6km bulk shear vector horizontal plot using the volume browser (under the "Fields" menu select "Convect" and choose "Shear Fields" to locate the product) on a WFO scale map to point out widespread sufficient shear (~ 45 kts) to support supercells over the whole CWA.
- Load a LAPS "Right Moving Supercell" storm motion horizontal plot to point out right moving supercell predicted motion of ~270° at 30 kts.
- Load a LAPS point sounding in Ulster county using the volume browser.
- Point out the significant surface-based instability (surface based ~2800 J/kg) with a low LCL (~4500 ft AGL) and almost no CIN.
- Point out that the moderate helicity values (~250 m^2/s^2 using LAPS estimated storm motion and the hodograph) is forecast to be realized considering the low-level instability.

- Point out that although wet-bulb zero heights are on the high end of optimal (10.6 kft), limiting the large hail threat from nonsupercells. However, supercells should still support large hail growth.
- Point out that there is significant damaging wind threat from any storm effectively utilizing the available CAPE since the boundary layer is unstable. Limitations to the wind threat include a relatively humid boundary lowest 4 km. However, midlevel dry air noted in the morning sounding at Pittsburgh may not be adequately analyzed by the LAPS.
- Point out that widespread flooding is not expected with relatively fast storm motions. However, any situation with training storms can increase this threat.

7. Inform the trainee that the flash flood guidance for the ALY CWA is approximately 2” for one hour, and 3” for three hours.

8. Summarize that the expected storm type is for supercell storms with tornado potential. The damaging wind and severe hail threat is moderate. Flash flooding threat is low due to relatively fast storm motions.

III. Simulation

The training objectives of this real-time simulation are to demonstrate:

- Ability to effectively use WarnGen to create warnings.
- Ability to effectively use WarnGen to issue severe weather statements as a follow up warning product.
- A timely routine for calling up products to evaluate the threat for tornadoes, hail, wind, and flooding.

This 2 hour simulation starts at 2200 UTC on May 31st, 1998, and ends at 0000 UTC on June 1st, 1998. The trainee will be asked to warn for the sector containing two storms south and southwest of the radar. The trainer should refer to the Section V Trainer Evaluation Guide to assist in determining the target storms and evaluating trainee performance.

Trainer Tasks

1. Explain the objectives to the trainee (see page 6-1).

2. State to the trainee that:

- There will be no pauses during the simulation.

- The trainer will be forwarding spotter reports to the trainee during the simulation.

3. Close down any existing D2D sessions, and start the simulation for the time period 2200 UTC on 2200 UTC on May 31st, 1998, to 0000 UTC on June 1st, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

4. Take about 10 minutes to show the trainee how to create a warning, follow-on severe weather statement, and how to save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under “File”, “Export to File...”.
- Type in the name of the warning at the end of the path in the “filename” box on the bottom of the popup window and click OK.

5. Inform the trainee to take 5-10 minutes to set up their D2D sessions and start warning.

6. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide on page 6-6 (consult image in Appendix A for graphical locations).

7. Evaluate the trainee’s ability to issue timely severe weather products and their warning routines using the Trainer Evaluation Guide on page 6-6.

8. At 0000 UTC (the end of the simulation), give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objective of this post simulation briefing is to discuss the trainee’s ability to issue timely severe weather products and their warning routines used in the simulation. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation completed during the simulation to focus discussion on relevant issues.

Trainer Tasks

1. Ask the trainee to self evaluate performance on:

- Using WarnGen to create warnings.

- Using WarnGen to issue severe weather statements as a follow-up warning product.
- Demonstrating a routine for evaluating threat for tornadoes, hail, wind, and flooding.

2. Discuss the observations of performance noted during the simulation. Utilize the warning files that were saved in the evaluation process.

V. Trainer Evaluation Guide

The focus of the real-time simulation is not on whether correct warning decisions were made; rather, it is on whether the warnings and severe weather statements were created properly and efficiently, and whether appropriate warning routines were used to evaluate the severe weather potential. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation:

Warnings

- Is the method of calculating the storm motion with WarnGen adequate? Does the trainee start at the end of a loop of 0.5° reflectivity and step back 3-4 frames before dragging the circle to the feature being tracked? Does the trainee step through the loop to insure the tracking is adequate and to correct any errors?
- Does the trainee click on the Redo Box button to redraw the box after obtaining an adequate storm motion?
- Does the trainee modify the polygon appropriately next to county boundaries? Are all the counties in the polygon selected correctly before the warning text is created?
- Is the duration of the warning appropriate for the workload?
- Does the trainee utilize the appropriate product type and optional bullets in choosing the text? Is the text modified to discuss only the primary threats specific to the storm being interrogated? Are they over-using call to action statements? Is the magnitude of the threat conveyed clearly in the warning (e.g. quarter size or baseball size hail)? Are spotter observations mentioned in the text?

- Does the trainee appear to read the warning before sending it out? Are there text mistakes in the warnings?
- Are the important cities in the path of the storm identified in the warning?
- If pathcasting is being used, is it overly precise given the uncertainty in the movement of the storm?
- Is the trainee falling behind in monitoring all the storms because of problems using WarnGen?

Severe Weather Statements

- Is the polygon moved and resized reasonably to where the storm is at the latest 0.5° reflectivity image in the loop?
- Is any new pertinent information being included in the statement (storm has intensified, weakened, showing signs of even larger hail)?
- Are the follow-on statements timely given the workload (at least one per warning)?
- Does the content of the statement reflect the locations and general content of the original warning?

Methodology

- Does the trainee evaluate each severe weather threat prior to creating the first warning?
- Are the product choices optimal to evaluating the threat?
- Is the trainee using all tilts Z/SRM to evaluate the latest data and three dimensional storm structure?
- Is the choice of tilts in the 4 panel chosen appropriately to sample the low, middle, and upper levels of the storm to look at temporal changes in the evolution?
- Is SRM being used to evaluate rotation?
- Is the 0.5° base velocity periodically checked for signs of strong ground-relative winds even though the wind threat is not high?
- Are the radar estimated precipitation totals being checked occasionally?
- Are the reflectivity characteristics in middle and upper levels being evaluated with all tilts Z/SRM and VIL for high reflectivity cores aloft for evaluating hail threat?

- Is base data used along with derived products (VIL, CR, radar algorithms)?
- Is satellite data being monitored for cold cloud tops and overshooting tops?
- Is lightning data being used to look for dense clusters of cloud to ground lightning indicating strong updrafts?
- Are changes in objective analysis fields such as LAPS CAPE/CIN, etc. being investigated at some time during the simulation?
- Are raw observations of the environment being investigated (surface obs, KENX VWP)?
- Are meso-analysis fields reviewed when the new surface observations are in at the top of the hour and when the new objective analysis fields are in at 20 minutes after the hour?
- Is the most recent data always being accessed when evaluating a storm?
- Is the trainee relying explicitly on the hail algorithm maximum estimated hail size in the warning, or are is the algorithm output used as general guidance?
- Is the trainee able to perform tasks and still keep up with new incoming data?

General Issues

Time (UTC)	Description
1801-0557 KBGM	radar data time period (limited radar products)
2002-0034 KENX	radar data time period (full set of radar products)
2156-2223 KBGM	radar data unavailable
2234-2250 KBGM	radar data unavailable

Storm Summary

During the simulation there are two storms south and southwest of the KENX radar to monitor. The first storm moves from Northern Sullivan to Ulster to

Columbia and Berkshire counties. This storm exhibits a three body scatter spike and a BWER. Only weak rotation was observed. Two delayed reports include 3/4” hail in Great Barrington, Berkshire CO. and severe winds in Saugerties, Ulster CO. The second storm is a long-tracked tornadic supercell moving eastward through Delaware County. A later damage survey indicated a tornado lasting for almost an hour, lifting just prior to the mesocyclone entering the CWA in Western Ulster County by 2300 UTC. This storm still maintained tornadic characteristics passing through the northern part of Ulster County, however the reflectivity and velocity data indicated that the storm weakened.

Northern Sullivan-Ulster- Columbia-Berkshire County storm

Time (UTC)	Description
2200 KENX	VIL=40 kg/m^2; MEHS=1”; 55dBZ to 22 kft MSL
2202 GOES 8	CTT min = -48^{o}C; No surrounding anvil
2210 KENX	2d circ V_r=35kt @15kft MSL; 55dBZ to 24kft; elevated 65dBZ and hail spike
2215 KENX	storm appears to be splitting; hailspike continues
2215 GOES-8	CTT min -57^{o}C. Larger anvil mass west overspreading this anvil.
2225 KENX	VIL = 50 kg/m^2; MEHS=1.5”; 55dBZ to 25 kft; hailspike continues.
2235 KENX	BWER 15-20kft MSL; hailspike decreased; Minor left split but main storm shows little rotation.
2241 KENX	hook-like appendage with weak divergent rotation at 0.5^o; WER > 12 kft; 55 dBZ to 21 kft.
2245 GOES 8	No CTT minima. IR cannot isolate this storm.
2246 KENX	VIL down to 40 kg/m^2; 55dBZ to 21 kft; MEHS=1.25”; New cell on right with elevated 50dBZ core. No WER with main cell.
2256 KENX	VIL down to 30 kg/m^2;
2306 KENX	VIL increased to 55 kg/m^2; 55dBZ to 30kft MSL; WER SW side; weak divergent meso at midlevels V_r~25kt.
2311 KENX	Intense core descending; 55 dBZ to 21 kft MSL; VIL down to 40 kg/m^2;MEHS = 1.5”
2321 KENX	55dBZ down to 15 kft MSL; VIL down to 30kg/m^2. MEHS< 1”

Time (UTC)	Description
2342 KENX	55 dBZ up to 21 kft MSL; VIL = 25 kg/m^2
2347 KENX	VIL up to 40 kg/m^2; MEHS=1”
0000 ALY	LSR#65: 0.75” hail at Great Barrington, Berkshire CO. MA. (likely 30 min delayed).
0000 ALY	LSR#66: Severe winds in Saugerties, Ulster CO. (likely 1hr late with this storm).

Considerations

- When does the trainee consider this storm for a warning?
- Does the trainee recognize and appropriately interpret the three-body scatter spike (hailspike) at 2210 UTC?
- Does the trainee notice that the cloud top temperatures are much warmer for this storm than the others to the north? This is likely due to a combination of the small anvil size (GOES IR resolution limitations) and that it is outside the large contiguous anvil mass to the north.
- Does the trainee note the BWER at 2235 UTC?
- Does the trainee note that this storm is not right-turning like other supercells?
- According to the trainee, is there enough evidence for this storm to be severe?
- If trainee does not consider this a severe storm, how does the trainee justify his/her decision making?

Delaware-Northern Ulster- Southern Greene County storm

Time (UTC)	Description
2241 KENX	We start describing a long-tracked tornadic supercell which struck Binghamton at this time. TVS/meso continues with VIL up to 60 kg/m^2.
2245 GOES 8	CTT minimum -67^{o}C, very near mean anvil temp; Warm wake
2250 KBGM	VIL = 50 kg/m^2; MEHS=1”
2250 BGM	LSR#30: Tornado in progress, struck Deposit, W. Delaware CO., NY.

Time (UTC)	Description
2251 KENX	TVS with 85kt LLDV; Meso and TVS are the same; WER on SW side; 55dBZ to 26kft MSL;
2255 KBGM	small hook with meso V_r=35kt, weakened from before. No more TVS; Classic supercell echo.
2256 KENX	TVS LLDV > 85kt; Meso V_r~45kt; hook; BWER; hailspike; Still in Delaware Co.
2301 KENX	55 dBZ up to 38 kft MSL, highest observed yet today.
2305 KBGM	VIL at 55 kg/m^2
2306 KENX	Dealiasing problem 0.5^o slice; 55 dBZ up to 41 kft MSL.
2310 KBGM	VIL up to 65 kg/m^2; MEHS=2”
2311 KENX	TVS LLDV down to >65 kt; Meso V_r~ 50 kt; VIL up to 70 kg/m^2; MEHS = 2.75”; 55 dBZ now to 46 kft!
2315 KBGM	VIL down to 55 kg/m^2;
2315 GOES 8	CTT minimum --67^{o}C; Warm wake
2316 KENX	TVS is unreliable; one inbound is in very low refl; Meso continues V_r~50kt; Enormous hailspike; BWER continues; VIL down to 55 kg/m^2; MEHS=3.25”.
2320 KBGM	MEHS up to 2.5”
2321 KENX	TVS w/better data, LLDV>76kt; Meso V_r>50kt; 60 dBZ to 37 kft; MEHS = 3.5”.
2326 KENX	TVS, LLDV>90 kts;
2330 KBGM	VIL decreased to 45 kg/m^2; Meso and TVS indicated by radar; MEHS down to 1”.
2331 KENX	Dealiasing problems lowest 2 slices; Meso V_r>45 kt, likely TVS just west of Ulster Co.; BWER; Hailspike decreased; VIL down to 50 kg/m^2; MEHS down to 1.5”
2330 BGM	LSR#30 cont’d: tornado finally lifted after crossing Broome and Delaware Counties. (lifting time not likely known in realtime). Hail reports at least baseball size.
2332 GOES 8	CTT minimum -67^{o}C; Warm wake
2336 KBGM	TDA lost TVS; No meso; VIL collapsed to 30 kg/m^2;

Time (UTC)	Description
2337 KENX	TVS LLDV > 95 kt on Ulster Co. border; Meso V_r>50kt; Core becmg more elongated; BWER losing definition; 55dBZ fell to 22 kft;VIL fell to 40 kg/m^2; MEHS=1.25”
2342 KENX	TVS LLDV>95 kt; Meso V_r>50kt; BWER almost gone; Forward flank core weakening; 55dBZ to 24 kft MSL; MEHS = 1.5”
2345 GOES 8	No CTT minimum; Warm wake
2347 KENX	TVS weakened LLDV down to 60 kts; Meso becmg more divergent V_r=45 kt; Smaller WER; 55 dBZ to 21 kft MSL.
2352 KENX	TVS LLDV 70 kts; Meso V_r ~40kts; Little BWER again but core is smaller than with last BWER; 55 dBZ to 21 kft MSL.VIL= 35 kg/m^2; MEHS=1.25”
2357 KENX	Lost TVS; Meso continues; strong WER and elevated 65dBZ core over meso; but FF flank core very strung out.

Considerations

- Is the trainee monitoring the progress of this storm and aware of its implications should it maintain itself when entering into the ALY CWA?
- Is trainee aware of the reasons behind the few numbers of LTGCG strikes with this cell? It is likely that this cell has an elevated charge layer due to a very strong updraft.
- How far ahead of time does the trainee issue a warning for Ulster County?
- Does the trainee use base data to evaluate the 3-D reflectivity structure of this storm?
- If the trainee issues a tornado warning, does it get discontinued due to the lack of reports?
- If a tornado warning is discontinued, what is the trainee’s reasoning?

7: Interval Based Simulation

I. Introduction

This simulation allows the trainee to develop critical thinking skills. To that end, the trainer and trainee should come to consensus through discussion when arriving at decision points.

The simulation focuses on the unique aspects of handling warning responsibility for a warning sector containing numerous storms in addition to the threat posed by a tornadic supercell approaching the CWA from the west. All severe weather threats are possible. At various points in the simulation, the WES trainer will pause the simulation and query the trainee about specific learning points. The trainer and trainee should discuss decisions based on the available information and expected outcomes. This simulation is appropriate for a warning forecaster who is proficient at issuing warnings and can benefit from practicing handling conflicting information and challenging warning workloads.

Objectives

The training objectives of this interval-based simulation are:

- Demonstrate effective methods of data interpretation.
- Demonstrate proper type and content of warnings.
- Demonstrate how to weigh information and handle uncertainty in the warning decision making process.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Post-simulation Briefing), and V (Trainer Evaluation Guide) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Issue warnings and follow up statements for a sector covering the storms in southern part of the CWA as shown in Figure C-2.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and discuss trainee briefing and sectorizing for this event.

Simulation: Manage the simulation, pause the simulation and discuss important learning issues, and interject spotter reports.

Post-Brief: Discuss trainee performance, any lessons learned from the simulation, and how they can be implemented at the local office.

This interval-based simulation is designed to take 3.5 hours to complete, with 30 minutes for the pre-simulation briefing, 2.0 hours for the simulation, 30 minutes for simulation discussion, and 30 minutes for the post-brief. The simulation starts at 2200 UTC on May 31st, 1998 and ends at 0000 UTC on June 1st, 1998. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sectors.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 2200 UTC on May 31st, 1998 to 0000 UTC on June 1st, 1998.

4. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

5. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the ALY CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

6. Instruct the trainee to:

- Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA,
- In order to maximize the benefit of the different scenario types, you may choose to ask the student about an optimal sectoring methodology,
- Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.

7. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

- 0-6 km shear 50 kts and BRN shear > 40 is supportive of supercell storms.
- Anvil-level SR flow (40 kts) suggests wet-end of classic supercells given isolated initiation.
- Low-level (0-3 km) shear is very strong (40 kts), higher just north of outflow boundary, enhancing supercell tornado potential. The 0-1 km shear has likely been increased the most just north of this boundary.
- Midlevel SR flow for right-moving supercells is 20 kts which is favorable for tornadoes.
- Morning soundings indicates a layer of dry air and steep lapse rates suggestive of an Elevated Mixed Layer (EML) at Pittsburgh. The buffalo soundings do not show an EML but also there is a much lower cap. The

Albany sounding shows elevated moisture surging over a warm frontal boundary.

- Surface dewpoint depressions 15° F or less allow for favorably low LCLs for tornadoes assuming surface dewpoints are well mixed in the boundary layer.
- Midlevel lapse rates are not indicated to be steep and the lack of analyzed midlevel dry air results in theta-E differences < 30° K from the surface to 600 mb. Wet microburst potential is generally low. However, highest potential would be in southern zones with access to dry midlevel air with steep lapse rates evident in the PBZ 12 UTC Skew-T.
- Large hail potential is significant given 20 kt storm-relative midlevel flow, strong shear and high CAPEs. Wet Bulb Zero (WBZ) values (~10.5-11 kft MSL) just above the optimal layer for greatest severe hail threat. Therefore, large hail potential is greatest for supercell storms, and limited for nonsupercells.
- The first wave of severe weather exited CWA leaving an outflow boundary across Northern Greene and Southern Rensselaer counties.
- Isolated supercells and short, severe wind producing line segments to the west of the CWA, plus reports of tornadoes out in Binghamton suggest atmosphere is capable of extreme severe weather. The mix of observed storm types suggests a full range of severe weather is possible in the next two hours in this CWA.
- Short-duration, heavy rain potential heightened due to storms realizing the high CAPE, and deep moisture. Rapid storm motion will minimize prolonged heavy rainfall. “Corfidi” vector motion is 20 kts suggesting that if a MCC does form, prolonged heavy rain potential is not likely.
- The 850 mb winds are strong suggesting rapid airmass recovery is possible behind initial cells.
- LAPS cannot analyze position of outflow boundary owing to the lack of METAR observations.
- In addition, high midlevel lapse rates are likely residing in the southern half of the CWA. LAPS is not depicting these lapse rates.

8. Make sure the trainee is comparing direct observations with any LAPS, or other diagnostic model output.

9. Inform the trainee that the flash flood guidance for the ALY CWA is approximately 2” for one hour, and 3” for three hours.

10. Point out on the SPC products provided in Appendix B that the CWA is in a high risk area, and a tornado watch has been issued with a threat for tornadoes, hail to 2 inches in diameter, and wind gusts to 70 kts.

III. Simulation

The training objectives of this interval-based simulation are to demonstrate effective methods of data interpretation, demonstrate proper type and content of warnings, and demonstrate how to weigh information and handle uncertainty in the warning decision making process. This simulation starts at 2200 UTC on May 31st, 1998 and ends at 0000 UTC on June 1st, 1998. At three times during the simulation (2225, 2316, 2357 UTC; unknown to the trainee), the simulation will be paused and the trainer will assess the trainee's warnings and methodology. Discussion is encouraged. For a storm-by-storm breakdown of important features in the data and important evaluation points, consult the Trainer Evaluation Guide on page 7-7.

Trainer Tasks

1. Explain the objectives to the trainee (see page 7-1).

2. State to the trainee that:

- There will be three pauses managed by the trainer, at surprise times, each lasting up to 10 minutes during the two hour simulation, at which times the trainer will query the trainee about their warnings and their methodology.
- The trainee should communicate any problem areas to the trainer when there are potentially severe storms crossing out of or into the warning sector outlined in the pre-simulation briefing.
- The trainer will be forwarding spotter reports to the trainee during the simulation.

3. Close down any existing D2D sessions, and start the simulation for the time period 2200 UTC on May 31st, 1998 to 0000 UTC on June 1st, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

4. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under “File”, “Export to File...”.

- Type in the name of the warning at the end of the path in the "filename" box on the bottom of the popup window and click OK.

5. Give the trainee 5-10 minutes to set up their D2D sessions.

6. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide (consult Appendix A for graphical locations).

7. At 2225 UTC pause the simulation for up to 10 minutes and ask:

    (1) "What are the current warnings out and why?"
    (2) "What is the expectation of these storms in the next 30 minutes?"

Get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Discuss the reasoning with the trainee and try to reach a consensus on the warning decision. Some considerations for discussion points include:

- the level of threat for all severe weather types,
- product choice,
- warning composition details,
- radar sampling issues,
- environmental analysis, and
- uncertainty in the decision making process.

8. Resume Simulation.

9. At 2316 UTC pause the simulation for up to 10 minutes and repeat **Step 7**.

10. Resume Simulation.

11. At 2357 UTC pause the simulation for up to 10 minutes and repeat **Step 7**.

12. End the simulation after last pause, and give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objectives of the post simulation briefing are to summarize the successes and failures of the warning process, and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation completed during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- The importance of evaluating high-wind potential in thunderstorms prior to the arrival of high wind reports.
- The feasibility of recognizing the tornadic potential in storms.
- The ability to calibrate radar products used to estimate hail size potential with real-time reports and modify previous expectations.
- The importance of evaluating data quality of the environment and radar data.

Trainer Tasks

1. Ask the trainee to:
   - Discuss the strengths and weaknesses of the data used in the decision making as well as the approach to analyzing the data.
   - Discuss any problems encountered with determining the type or content of the warnings.
   - Discuss the challenges of synthesizing the warning inputs and the sources of uncertainty.

2. Review the reports and the times to compare to the warnings.

3. Discuss the lessons learned from the event, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objectives of this interval-based simulation are to demonstrate effective methods of data interpretation, demonstrate proper type and content of warnings, and demonstrate how to weigh information and handle uncertainty in the warning decision making process. Part of the evaluation can be done during the query sessions in the simulation, and more evaluation can be done while the trainee is actively involved in the warning operations during the simulation. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation:

General Issues

Time (UTC)	Description
1801-0557 KBGM	radar data time period (limited radar products)
2002-0034 KENX	radar data time period (full set of radar products)
2156-2223 KBGM	radar data unavailable
2234-2250 KBGM	radar data unavailable

Considerations

- Does the trainee anticipate the areas of highest expected threat of severe weather based on the position of the gust front laid out by storms in the previous two hours, strong values of 0-3 km and 0-1 km SRH/shear, high SBCAPE south of the boundary, lower CAPE north of the boundary.
- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?
- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, and LAPS)?
- Does the trainee recognize that LAPS cannot adequately analyze surface fields within the Catskill or Berkshire mountains owing to the lack of surface data?
- Does the trainee analyze where the outflow boundary in the correct position so that the proper adjustments can be made to the LAPS near-surface temperature, dewpoint and instability fields?
- Does the trainee use the VWP products from KBGM and KENX to compare with the wind fields analyzed by LAPS?

- Does the trainee also use the VWP products to estimate the depth of the outflow boundary left over from the previous convection? And that strong 850 mb winds are providing lift over the outflow boundary?

Storm Summary

During this part of the simulation, a second round of severe thunderstorms crosses the ALY CWA. A thunderstorm outflow boundary, which has been left behind the first wave of convection, has settled southward to an east-west line near the Greene, Albany County border. However, its exact position within the complicated terrain of eastern New York is unable to be determined. Very strong low-level and deep layered shear continues across the area, however surface-based instability has been significantly reduced north of the outflow boundary.

The most significant cluster of convection needing attention includes an HP supercell, with a history of large tornadoes, which rapidly evolves into a bow echo as it enters the CWA in Schoharie and Albany counties. The bow echo weakens and a new updraft grows on the surging outflow boundary leading to a new severe bow echo across Southern Albany into Southern Rensselaer counties, likely following the outflow boundary. An updraft responsible for the new bow developed rotation and a BWER just before an F2 tornado touched down in Southern Rensselaer county. This bow quickly moved east into Massachusetts with just a few wind damage reports.

A squall line segment extending northeast of the bow echo complex was not impressive from a storm structure standpoint, however it supported an organized Rear Inflow Jet (RIJ) structure and the gust front remained fairly close to the leading edge of the core. Base velocity measurements within the RIJ suggested severe winds are likely as the RIJ mixes high momentum air downward to the surface. Several severe wind reports from Montgomery to Fulton county supported the radar observations. More high wind reports ensued as the squall line segment passed east into Schenectady, Saratoga, Bennington and Northern Rensselaer counties.

Several cells east of the squall line segment developed over the cold dome became severe. The most significant cell developed in Northern Albany county early in this period and moved into Northern Rensselaer, and Southern Bennington County, Vermont before merging with the squall line segment moving in Windham County. This storm produced occasional periods of rotation, WERs and high reflectivities at high altitudes. Reports of golf ball-sized hail confirmes the hail potential of this one cell.

Another area of concern includes the development of supercells along the trailing gust front of the main bow echo complex in Northern Greene County. Two mesocyclones with occasional BWERs requires attention regarding whether a tornado warning is necessary. There is no ground-truth with these storms.

An isolated hail-producing cell tracking from Ulster County into Berkshire County, Massachusetts also requires attention. This storm is unusually steady state and is marginally severe for the entire period of this simulation.

Finally, a long-tracked tornadic supercell recently struck Binghamton and is moving steadily eastward through Delaware County, with a long-tracked tornado for almost an hour. This storm reaches the CWA in Ulster County during the later part of the simulation supporting a TVS, mesocyclone, hook echo and a BWER. The 55dBZ core reaches almost 41 kft with this storm, the highest of any during this simulation period. However, soon after entering Ulster County, the storm slowly weakens. Although it still contains strong rotation and evidence for very large hail, no reports are received from this mountainous, sparsely populated part of the county.

Flash flooding is also a concern. Earlier convection laid down two paths of > 1” of rainfall, one on either side of the KENX RDA. The large HP supercell/bow echo complex adds rainfall to both these paths, especially the one south of the RDA. A short period of echo training along the trailing gust front produces 2-3” of additional rainfall within one hour in Northern Greene County with another in central Schoharie County. This rainfall track runs into southern Rensselaer county. Another rainfall track of greater than 2.5” runs through northern Rensselaer into Bennington County, Vermont. Both of these tracks likely are exaggerated from hail contamination. In addition, no significant flooding was reported anywhere in the Albany CWA.

Eastern Delaware - Northern Greene County storms

Time (UTC)	Description
2251 KENX	New updraft far northwest corner; 55dBZ to 18kft MSL, elevated core. VIL only 25 kg/m^2.

Time (UTC)	Description
2256 KENX	elevated meso V_r~30kt in E. Delaware Co. storm; storm in W. Greene Co. has weaker meso, WER and elevated core 55dBZ to 18kft MSL. VIL unchgd
2300 KBGM	VIL only 30 kg/m^2 for both cells.
2301 KENX	Meso V_r up to 40 kt but still elevated in E. Delaware Co. 55dBZ up to 23kft MSL; 55dBZ up to 26kft MSL in NW Greene Co.; Both storms with VIL = 50 kg/m^2 & MEHS up to 1”.
2305 KBGM	VIL still at 30 kg/m^2; meso indicated by algorithm.
2306 KENX	E. Delaware Co. cell: Meso descended to 0.5^o (2.5kft AGL); BWER and 55 dBZ to 38kft; VIL up to 60 kg/m^2; NW Greene Co. cell: Lost coherent circulation. MEHS=1.75”
2310 KBGM	VIL up to 40 kg/m^2; MEHS < 1”
2311 KENX	55dBZ to 41 kft MSL; outflow from bow to NE undercutting meso.
2315 KBGM	VIL holding at 40 kg/m^2.
2315 GOES 8	CTT minimum=-71^oC; Almost indistinct.
2316 KENX	elevated meso V_r~40 kts; BWER dissipated; WER leftover 221^o@24nm; VIL up to 65 kg/m^2;
2320 KBGM	VIL down to 30kg/m^2;
2321 KENX	55dBZ to 31 kft;VIL down to 55kg/m^2; MEHS=1.5”.
2325 KBGM	VIL down to 25kg/m^2.
2326 KENX	New elevated core just SW of main cell; VIL = 50kg/m^2. MEHS down to 1”.
2331 KENX	Meso intensified to V_r=50kt but elevated above outflow; BWER developed 203^o@18nm; 55 dBZ to 26 kft; Another elevated meso V_r=30 kt 161^o@12nm;
2332 GOES 8	CTT minimum = -70^oC
2337 KENX	Cell appears to be gaining on outflow bndry from bow; VIL down to 40 kg/m^2; Could be cone of silence effect; Other parameters remain the same.
2345 GOES 8	No significant CTT minimum or warm wake
2347 KENX	Meso less symmetrical but V_r still ~50kts; BWER gone but large WER continues;

Time (UTC)	Description
2352 KENX	Meso more disorganized with V_r ~40kts;
2357 KENX	Meso continues but weak LL convergence; WER; 55dBZ to 25kft MSL.

Considerations

- When does the trainee begin to consider a warning for this storm? First major updraft pulse occurs 2301 UTC with a 55 dBZ core to 26 kft.
- What hail size does the trainee consider around 2306 UTC? The trainee should notice the BWER, mesocyclone and one of the higher cores in this simulation.
- Does the trainee notice the relatively few LTGCG strikes, even during the intense phase of this storm? This might indicate an elevated charge structure consistent with some supercells.
- Does the trainee compare data from KBGM and KENX with this storm? If so, the trainee might notice that the VILs are considerably lower from KBGM.
- Does the trainee note that this supercell is passing north of the outflow boundary left by the bowing storm to its northeast?
- Does the trainee issue a tornado warning, and if so, what are the justifications?
- Does the trainee note the reduction in VIL at 2337 UTC might be from the cone of silence effect?
- Does the trainee know to use higher elevation slices (greater than 3.4°) to look for evidence of WERs or BWERs as the storm passes close to the KENX RDA?

Northern Sullivan-Ulster- Columbia-Berkshire County storm

Time (UTC)	Description
2200 KENX	VIL=40 kg/m^2; MEHS=1”; 55dBZ to 22 kft MSL
2202 GOES 8	CTT min = -48^{o}C; No surrounding anvil
2210 KENX	2d circ V_r=35kt @15kft MSL; 55dBZ to 24kft; elevated 65dBZ and hail spike
2215 KENX	storm appears to be splitting; hailspike continues

Time (UTC)	Description
2215 GOES-8	CTT min -57^{o}C. Larger anvil mass west overspreading this anvil.
2225 KENX	VIL = 50 kg/m^2; MEHS=1.5”; 55dBZ to 25 kft; hailspike continues.
2235 KENX	BWER 15-20kft MSL; hailspike decreased; Minor left split but main storm shows little rotation.
2241 KENX	hook-like appendage with weak divergent rotation at 0.5^{o}; WER > 12 kft; 55 dBZ to 21 kft.
2245 GOES 8	No CTT minima. IR cannot isolate this storm.
2246 KENX	VIL down to 40 kg/m^2; 55dBZ to 21 kft; MEHS=1.25”; New cell on right with elevated 50dBZ core. No WER with main cell.
2256 KENX	VIL down to 30 kg/m^2;
2306 KENX	VIL increased to 55 kg/m^2; 55dBZ to 30kft MSL; WER SW side; weak divergent meso at midlevels V_r~25kt.
2311 KENX	Intense core descending; 55 dBZ to 21 kft MSL; VIL down to 40 kg/m^2;MEHS = 1.5”
2321 KENX	55dBZ down to 15 kft MSL; VIL down to 30kg/m^2. MEHS< 1”
2342 KENX	55 dBZ up to 21 kft MSL; VIL = 25 kg/m^2
2347 KENX	VIL up to 40 kg/m^2; MEHS=1”
0000 ALY	LSR#65: 0.75” hail at Great Barrington, Berkshire CO. MA. (likely 30 min delayed).
0000 ALY	LSR#66: Severe winds in Saugerties, Ulster CO. (likely 1hr late with this storm).

Considerations

- When does the trainee consider this storm for a warning?
- Does the trainee recognize and appropriately interpret the three-body scatter spike (hailspike) at 2210 UTC?
- Does the trainee notice that the cloud top temperatures are much warmer for this storm than the others to the north? This is likely due to a combination of the small anvil size (GOES IR resolution limitations) and that it is outside the large contiguous anvil mass to the north.
- Does the trainee note the BWER at 2235 UTC?

- Does the trainee note that this storm is not right-turning like other supercells?
- According to the trainee, is there enough evidence for this storm to be severe?
- If trainee does not consider this a severe storm, how does the trainee justify his/her decision making?

Delaware-Northern Ulster- Southern Greene County storm

Time (UTC)	Description
2241 KENX	We start describing a long-tracked tornadic supercell which struck Binghamton here.TVS/meso continues with VIL up to 60 kg/m^2.
2245 GOES 8	CTT minimum -67^{o}C, very near mean anvil temp; Warm wake
2250 KBGM	VIL = 50 kg/m^2; MEHS=1”
2250 BGM	LSR#30: Tornado in progress, struck Deposit, W. Delaware CO., NY.
2251 KENX	TVS with 85kt LLDV; Meso and TVS are the same; WER on SW side; 55dBZ to 26kft MSL;
2255 KBGM	small hook with meso V_r=35kt, weakened from before. No more TVS; Classic supercell echo.
2256 KENX	TVS LLDV > 85kt; Meso V_r~45kt; hook; BWER; hailspike; Still in Delaware Co.
2301 KENX	55 dBZ up to 38 kft MSL, highest observed yet today.
2305 KBGM	VIL at 55 kg/m^2
2306 KENX	Dealiasing problem 0.5^o slice; 55 dBZ up to 41 kft MSL.
2310 KBGM	VIL up to 65 kg/m^2; MEHS=2”
2311 KENX	TVS LLDV down to >65 kt; Meso V_r~ 50 kt; VIL up to 70 kg/m^2; MEHS = 2.75”; 55 dBZ now to 46 kft!
2315 KBGM	VIL down to 55 kg/m^2;
2315 GOES 8	CTT minimum --67^{o}C; Warm wake
2316 KENX	TVS is unreliable; one inbound is in very low refl; Meso continues V_r~50kt; Enormous hailspike; BWER continues; VIL down to 55 kg/m^2; MEHS=3.25”.
2320 KBGM	MEHS up to 2.5”

Time (UTC)	Description
2321 KENX	TVS w/better data, LLDV>76kt; Meso V_r>50kt; 60 dBZ to 37 kft; MEHS = 3.5”.
2326 KENX	TVS, LLDV>90 kts;
2330 KBGM	VIL decreased to 45 kg/m^2; Meso and TVS indicated by radar; MEHS down to 1”.
2331 KENX	Dealiasing problems lowest 2 slices; Meso V_r>45 kt, likely TVS just west of Ulster Co.; BWER; Hailspike decreased; VILdown to 50 kg/m^2; MEHS down to 1.5”
2330 BGM	LSR#30 contd: tornado finally lifted after crossing Broome and Delaware COs. (lifting time not likely known in realtime). Hail reports at least baseball size.
2332 GOES 8	CTT minimum --67^{o}C; Warm wake
2336 KBGM	TDA lost TVS; No meso; VIL collapsed to 30 kg/m^2;
2337 KENX	TVS LLDV > 95 kt on Ulster Co. border; Meso V_r>50kt; Core becmg more elongated; BWER losing definition; 55dBZ fell to 22 kft;VIL fell to 40 kg/m^2; MEHS=1.25”
2342 KENX	TVS LLDV>95 kt; Meso V_r>50kt; BWER almost gone; Forward flank core weakening; 55dBZ to 24 kft MSL; MEHS = 1.5”
2345 GOES 8	No CTT minimum; Warm wake
2347 KENX	TVS weakened LLDV down to 60 kts; Meso becmg more divergent V_r=45 kt; Smaller WER; 55 dBZ to 21 kft MSL.
2352 KENX	TVS LLDV 70 kts; Meso V_r ~40kts; Little BWER again but core is smaller than with last BWER; 55 dBZ to 21 kft MSL.VIL= 35 kg/m^2; MEHS=1.25”
2357 KENX	Lost TVS; Meso continues; strong WER and elevated 65dBZ core over meso; but FF flank core very strung out;

Considerations

- Is the trainee monitoring the progress of this storm and aware of its implications should it maintain itself when entering into the ALY CWA?
- Is trainee aware of the reasons behind the few numbers of LTGCG strikes with this cell? It is likely that this cell has an elevated charge layer due to a very strong updraft.
- How far ahead of time does the trainee issue a warning for Ulster County?

- Does the trainee use base data to evaluate the 3-D reflectivity structure of this storm?
- If the trainee issues a tornado warning, does it get discontinued due to the lack of reports?
- If a tornado warning is discontinued, what is the trainee’s reasoning?

8: Situation Awareness Simulation

I. Introduction

This simulation focuses on the unique aspects of handling warning responsibility for a warning sector containing several storms with different structural characteristics. This simulation is appropriate for a warning forecaster with intermediate level of expertise who is proficient with the mechanics of issuing warnings. At three times, unknown to the trainee, the simulation will be paused for the trainer to evaluate the trainee's situation awareness.

Objective

The training objective of this situation awareness simulation is:

- Demonstrate the three levels of situation awareness (perceive, comprehend, project) during a challenging warning situation.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Post-simulation Briefing), and V (Trainer Evaluation Guide) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Issue warnings and follow up statements for the sector containing the storm that produces the extreme damaging wind event.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and document trainee briefing and sectorizing for this event.

Simulation: Manage the simulation, pause the simulation to query the trainee's level of situation awareness, evaluate the performance of the trainee, and interject spotter reports.

Post-Brief: Discuss trainee performance and any lessons learned from the simulation and how they can be implemented at the local office.

This situation awareness simulation is designed to take 3.25 hours to complete, with 30 minutes for the pre-simulation briefing, 2.0 hours for the simulation, 30 minutes for querying, and 15 minutes for the post-brief. The simulation starts at 2200 UTC on May 31st, 1998 and ends at 0000 UTC on June 1st, 1998. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sectors.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 2200 UTC on May 31th, 1998 to 0000 UTC on June 1st, 1998.

4. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

5. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the ALY CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

6. Instruct the trainee to:

- Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA.
- In order to maximize the benefit of the different scenario types, in a sector sector illustrated in Figure C-2 on page C-3. However, you may choose to ask the student about an optimal sectoring methodology.
- Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.

7. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

- 0-6 km shear 50 kts and BRN shear > 40 is supportive of supercell storms.
- Anvil-level SR flow (40 kts) suggests wet-end of classic supercells given isolated initiation.
- Low-level (0-3 km) shear is very strong (40 kts), higher just north of outflow boundary, enhancing supercell tornado potential. The 0-1 km shear has likely been increased the most just north of this boundary.
- Midlevel SR flow for right-moving supercells is 20 kts which is favorable for tornadoes.
- Morning soundings indicates a layer of dry air and steep lapse rates suggestive of an Elevated Mixed Layer (EML) at Pittsburgh. The buffalo soundings do not show an EML but also there is a much lower cap. The Albany sounding shows elevated moisture surging over a warm frontal boundary.
- Surface dewpoint depressions 15° F or less allow for favorably low LCLs for tornadoes assuming surface dewpoints are well mixed in the boundary layer.
- Midlevel lapse rates are not indicated to be steep and the lack of analyzed midlevel dry air results in theta-E differences < 30° K from the surface to 600 mb. Wet microburst potential is generally low. However, highest potential would be in southern zones with access to dry midlevel air with steep lapse rates evident in the PBZ 12 UTC Skew-T.

- Large hail potential is significant given 20 kt storm-relative midlevel flow, strong shear and high CAPEs. Wet Bulb Zero (WBZ) values (~10.5-11 kft MSL) just above the optimal layer for greatest severe hail threat. Therefore, large hail potential is greatest for supercell storms, and limited for nonsupercells.
- The first wave of severe weather exited CWA leaving an outflow boundary across Northern Greene and Southern Rensselaer counties.
- Isolated supercells and short, severe wind producing line segments to the west of the CWA, plus reports of tornadoes out in Binghamton suggest atmosphere is capable of extreme severe weather. The mix of observed storm types suggests a full range of severe weather is possible in the next two hours in this CWA.
- Short-duration, heavy rain potential heightened due to storms realizing the high CAPE, and deep moisture. Rapid storm motion will minimize prolonged heavy rainfall. “Corfidi” vector motion is 20 kts suggesting that if a MCC does form, prolonged heavy rain potential is not likely.
- The 850 mb winds are strong suggesting rapid airmass recovery is possible behind initial cells.
- LAPS cannot analyze position of outflow boundary owing to the lack of METAR observations.
- In addition, high midlevel lapse rates are likely residing in the southern half of the CWA. LAPS is not depicting these lapse rates.

8. Make sure the trainee is comparing direct observations with any LAPS, or other diagnostic model output.

9. Inform the trainee that the flash flood guidance for the ALY CWA is approximately 2” for one hour, and 3” for three hours.

10. Point out on the SPC products provided in Appendix B that the CWA is in a high risk area, and a tornado watch has been issued with a threat for tornadoes, hail to 2 inches in diameter, and wind gusts to 70 kts.

III. Simulation

The training objective of this situation awareness simulation is to demonstrate three levels of situation awareness during a challenging warning situation. This 2 hour simulation starts at 2200 UTC on May 31st, 1998, and ends at 0000 UTC on June 1st, 1998. At three times during the simulation (2230, 2316, 2357 UTC

UTC; unknown to the trainee), the simulation will be paused and the trainer will assess the trainee's situation awareness by evaluating:

- Has the trainee perceived data relevant to all the severe weather threats (spotter reports, expiration times of current warnings, etc.)?
- Does the trainee understand the meaning of the data? (What warnings are needed?)
- Has the trainee formed an expectation based on these data? (Will the threat change over time?)

For a storm-by-storm breakdown of important features in the data and important evaluation points, consult the Trainer Evaluation Guide on page 8-8.

Trainer Tasks

1. State to the trainee that:

- The objectives of the simulation are to demonstrate the ability to perceive warning related inputs, understand the meaning of the assessment and project this into expectations and actions.
- There will be three pauses managed by the trainer, at surprise times, each lasting up to 10 minutes during the 2.0 hour simulation. At which times the trainer will ask.
    (1) "What is the current state of the severe potential and why?"
    (2) "What is the expectation of these storms in the next 30 minutes?"
    (3) "When will the current warnings expire?"
- The trainee should communicate any problem areas to the trainer when there are potentially severe storms crossing warning sectors.
- The trainer will be forwarding spotter reports to the trainee during the simulation.

2. Close down any existing D2D sessions, and start the simulation for the time period 2200 UTC on May 31st, 1998 to 0000 UTC on June 1st, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

3. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under "File", "Export to File...".

- Type in the name of the warning at the end of the path in the "filename" box on the bottom of the popup window and click OK.

4. Give the trainee 5-10 minutes to set up their D2D sessions.

5. During the simulation, provide storm reports as spotter reports. Use the reports listed in the storm time line tables within this section. The reports listed in the Trainer Evaluation Guide on page 8-8 (consult image in Appendix A for graphical locations) can be referred to as well.

6. At 2230 UTC pause the simulation for up to 10 minutes and ask:

(1) "What is the current state of the severe potential and why?"

(2) "What is the expectation of these storms in the next 30 minutes?"

(3) "When will the current warnings expire?"

- Try to get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Document the reasoning, and take note of any significant severe weather cues not recognized. Pay particularly close attention to whether the trainee has noticed the high wind threat for a line of storms in Montgomery and Fulton County.
- If the trainee is "lost" or behind, document the reason. If corrective measures are needed to "reengage" them, make adjustments before resuming.

7. Resume the simulation.

8. At 2316 pause the simulation and ask:

(1) "What is the current state of the severe potential and why?"

(2) "What is the expectation of these storms in the next 30 minutes?"

(3) "When will the current warnings expire?"

- Try to get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Document the reasoning, and take note of any significant severe weather cues not recognized. Pay particularly close attention to whether the trainee has evaluated the tornado threat to the developing bow in far Eastern Albany County. In particular, has the trainee noted the presence of a BWER overlying a deep convergence zone and co-located with rotation?
- If the trainee is "lost" or behind, document the reason. If corrective measures are needed to "reengage" them, make adjustments before resuming.

9. Resume the simulation.

10. At 2357 pause the simulation and ask:

(1) “What is the current state of the severe potential and why?”

(2) “What is the expectation of these storms in the next 30 minutes?”

(3) “When will the current warnings expire?”

- Try to get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Document the reasoning, and take note of any significant severe weather cues not recognized. In particular, evaluate whether the trainee has evaluated the flash flood potential from Southern Schoharie eastward to Southern Rensselaer county.
- If the trainee is “lost” or behind, document the reason. If corrective measures are needed to “reengage” them, make adjustments before resuming.

11. End the simulation, and give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objective of the post simulation briefing is to summarize the successes and failures of the warning process and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation done during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- Maintaining a high level of situation awareness throughout.
- Recognizing multiple severe weather threats with the storms.
- Recognizing early development of bow echo and supercell signatures.
- Understanding the significance of features relating to the development of extreme winds (e.g. elevated rear-inflow jet, supercell structure in the bow echo, deep convergence).
- Maintaining the big picture issues while periodically focussing on the details.

Trainer Tasks

1. Ask the trainee to:

- Discuss problems encountered with perceiving warning related inputs.
- Discuss any warning related inputs that were particularly challenging to understand.
- Discuss problems encountered with formulating expectations and actions.

2. Review the reports and the times to compare to the warnings.

3. Discuss the key issues of the event and any lessons learned, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objective of this situation awareness simulation is for the trainee to demonstrate the three levels of situation awareness (perceive, comprehend, and project) during a challenging warning situation. Part of the evaluation can be done during the query sessions, and more evaluation can be done while the trainee is actively involved in the warning operations. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation:

General Issues

Time (UTC)	Description
1801-0557 KBGM	radar data time period (limited radar products)
2002-0034 KENX	radar data time period (full set of radar products)
2156-2223 KBGM	radar data unavailable
2234-2250 KBGM	radar data unavailable

Considerations

- Does the trainee anticipate the areas of highest expected threat of severe weather based on the position of the gust front laid out by storms in the previous two hours, strong values of 0-3 km SRH/shear, high SBCAPE south of the boundary, lower CAPE north of the boundary.
- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?
- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, and LAPS)?
- Does the trainee recognize that LAPS cannot adequately analyze surface fields within the Catskill or Berkshire mountains owing to the lack of surface data?
- Does the trainee analyze where the outflow boundary in the correct position so that the proper adjustments can be made to the LAPS near-surface temperature, dewpoint and instability fields?
- Does the trainee use the VWP products from KBGM and KENX to compare with the wind fields analyzed by LAPS?
- Does the trainee also use the VWP products to estimate the depth of the outflow boundary left over from the previous convection? And that strong 850 mb winds are providing lift over the outflow boundary?

Storm Summary

During this part of the simulation, second round of severe thunderstorms crossed the ALY CWA. A thunderstorm outflow boundary, which has been left behind the first wave of convection, has settled southward to an east-west line near the Greene, Albany county border. However, its exact position within the complicated terrain of Eastern New York is unable to be determined. Very strong low-level and deep layered shear continues across the area, however surface-based instability has been significantly reduced north of the outflow boundary. Three areas of storms cross the sector of the CWA identified for this simulation.

The most significant cluster of convection needing attention includes an HP supercell, with a history of large tornadoes, which rapidly evolves into a bow echo as it enters the CWA in Schoharie and Albany counties. The bow echo weakens and a new updraft grows on the surging outflow boundary leading to a new severe bow echo across Southern Albany into Southern Rensselaer counties, likely following the outflow boundary. An updraft responsible for the new bow developed rotation and a BWER just before an F2 tornado touched down in Southern Rensselaer county. This bow quickly moved east into Massachusetts with just a few wind damage reports.

A squall line segment extending northeast of the bow echo complex was not impressive from a storm structure standpoint, however it supported an organized Rear Inflow Jet (RIJ) structure and the gust front remained fairly close to the leading edge of the core. Base velocity measurements within the RIJ suggested severe winds are likely as the RIJ mixes high momentum air downward to the surface. Several severe wind reports from Montgomery to Fulton county supported the radar observations. More high wind reports ensued as the squall line segment passed east into Schenectady, Saratoga, Bennington and Northern Rensselaer counties.

Several cells east of the squall line segment developed over the cold dome became severe. The most significant cell developed in Northern Albany county early in this period and moved into Northern Rensselaer, and Southern Bennington County, Vermont before merging with the squall line segment moving in Windham County. This storm produced occasional periods of rotation, WERs and high reflectivities at high altitudes. Reports of golf ball-sized hail confirmed the hail potential of this one cell.

Flash flooding was also a concern. Earlier convection laid down two paths of > 1” of rainfall, one on either side of the KENX RDA. The large HP supercell to bow echo complex moved added rainfall to both these paths, especially the one south of the RDA. A short period of echo training along the trailing gust front produced 2-3” of additional rainfall within one hour in Northern Greene County with another in Central Schoharie County. This rainfall track runs into Southern Rensselaer county. Another rainfall track of greater than 2.5” runs through Northern Rensselaer into Bennington County, Vermont. Both of these tracks likely are exaggerated from hail contamination. In addition, no significant flooding was reported anywhere in the Albany CWA.

Otsego-Schoharie - Albany - Rensselaer - Berkshire County Storm

Time (UTC)	Description
2156 KBGM	Meso V_r=45kt @054°38nm; no alg TVS but LLDV>70kt; VIL=60kg/m^2; MEHS=1.5”
2200 KENX	TVS>76 kt LLDV 269°53nm; Thick hook with BWER above; VIL=65 kg/m^2; MEHS=2”.
2200 BGM	LSR#18: Tornado reported near North Norwich, Chenango CO (likely very late report with this storm)
2205 KENX	TVS > 65 kt LLDV 270^{o}50nm; new meso firming up to the SE
2202 GOES-8	IR minimum cloud top temp -71°C; surrounding anvil=-63°C. EV
2210 KENX	TVS>66 kt LLDV @271°47nm; New large meso; hook encircled meso; doughnut hole 10kft MSL; VIL> 70 kg/m^2; MEHS=1.5”.
2215 KENX	TVS in new meso intensified with LLDV > 95kt; Double meso structure with TVS in new one to east; Core is wrapping around meso; VIL down to 55 kg/m^2 POSH>70&% MEHS = 2” KOAX MEHS = 1.25”; RFD igniting convection to the SE
2215 GOES 8	CTT min up to -68^{o}C; EV still apparent
2220 KENX	TVS dissipated; strong meso; Core wrapped around meso and RFD has ignited convection; VIL sharply down to 35 kg/m^2; MEHS below 1”; Large area of >64 kt inbounds in RFD
2225 KENX	New cell in S. Schoharie Co. ahead of bowing RFD segment has 55dBZ to 24 kft. Meso now a comma head with deeper cells along RFD to the south. No TVS
2225 LTGCG	5 minute LTGCG decreases rapidly in comma head area

Time (UTC)	Description
2230 GOES 8	Lost CTT min over meso. New CTT min -71^{o}C with new lead cell in S. Schoharie Co.
2230 KENX	Area of >64 kt inbounds entering Schoharie with RFD.
2225-2230 BGM	LSR#24: tornado Portlandville-Maryland, Otsego CO.
2232 GOES-8	CTT min=-71^{o}C over lead cell; Double warm wake, one over comma head, second developed over flanking line cell.
2235 KENX	Multiple meso detections along old RFD. Also strong anticy-clonic rotation on S side of rear inflow notch; 55 dBZ to 24 kft on flanking line; VIL up to 50 kg/m^{2}; MEHS up to 1.25”.
2230-2235 BGM	LSR#29: tornado with major forest damage from Laurens to Mil-ford, Otsego CO. House damage reported too. This report is likely 15-20 minutes late.
2235 ALY	LSR#46: Severe wind reported in Richmondville, Schoharie CO.
2241 KENX	Comma head still producing >64kt inbounds @273^{o} 20nm. Flanking line core stronger; 55dBZ to 36kft @ 250^{o} 27nm; VIL up to 65 kg/m^{2}.
2245 GOES-8	CTT min = -69^{o}C with EV over Schoharie Co. CTT = -68^{o}C over Albany CO too.
2247 ALY	LSR#47-48: 0.75” hail North Blenheim, and severe wind in Breakabeen, Schoharie CO.
2250 KBGM	VIL down to 30 kg/m^{2}. Overly large meso detection is elevated.
2251 KENX	0.5^{o} Vel inbounds down to 50kt E. Schoharie Co. 960’ AGL. Mul-tiple meso detections along gust front, all elevated/shallow; VIL down to 40 kg/m^{2}, in Schoharie Co. MEHS to 1”.
2300 KBGM	VIL up to 30 kg/m^{2} but MEHS < 1”
2301 KENX	Core over radar; VIL cut down by cone of silence; Convergence over 11 kft deep 8-10 mi S. of RDA;
2306 KENX	>64kt outbound 135^{o}@4nm Deep vertical conv zone to 13 kft S of max outbound; Conv increasing; VIL truncated by cone;
2310 KBGM	VIL up to 50 kg/m^{2}; MEHS = 1”
2311 KENX	Meso in SRM 104^{o}@9nm above 0.5^{o} refl inflow notch; WERs or BWERs along leading edge of core 100^{o}@10nm to 130^{o}@13nm; Expanding > 64kt outbounds centered 116^{o}@8nm

Time (UTC)	Description
2308-2311 ALY	LSR#50&52: Severe winds Clarksville, New Scotland, Albany CO just SW of Albany.
2315 KBGM	VIL down to 40 kg/m^2; MEHS = 1.0”
2315 GOES 8	CTT minima -71^{o}C; Warm wake
2316 KENX	Area >64kt outbounds at 105^o@12nm; Strong BWER 087^o@13nm; Meso V_r~‘40 kt associated; rear notch to the south; VIL coming up with better sampling
2321 KENX	Meso V_r=45 kts 090^o@17nm; BWER starts ~ 6kft MSL.; 55dBZ to 29kft; Storm emerging from cone of silence; VIL=45kg/m^2; MEHS=1.5”
2326 KENX	LLDV 50kt, almost TVS 091^o@20nm; Meso with V_r=40kt ovhd; Still deep conv zone to 20kft MSL south of TVS; BWER weakened still larger WER with meso; 55dBZ to 25 kft MSL.
2331 KENX	Large >64 kt outbounds centered 090^o@25nm; Another >64kt outbound centered 119^o@19nm; BWER dissipated; Large rear inflow notch; 55 dBZ to 28 kft MSL; VIL up to 55 kg/m^2; MEHS = 1.25”.
2332 GOES 8	Lost CTT minima but warm wake continues
2322-2332 ALY	LSR#55: Tornado (late report), 1.5 NNW East Shodack to 3.4 ENE Millers Corners, S. Rensselaer CO.
2337 KENX	New WERs at apex of bow; No more meso, or asymmetrical; Deep conv zone continues at bow apex; 55dBZ to 24 kft MSL; VIL at 45 kg/m^2; MEHS=1.5”.
2330-2337 ALY	LSR#56-58: Severe winds at New Scotland, Albany CO., Greenville, N. Greene CO., and Schoharie in Schoharie CO. (likely late report)
2340 ALY	LSR#60: Severe winds in New Baltimore, far NE Greene CO.
2342 KENX	WER is shallower at apex of bow otherwise no major changes
2342 ALY	LSR#61: 0.75” hail Stephentown, SE Rensselaer CO.
2345 GOES 8	No CTT minima and warm wake lost definition
2347 KENX	Large > 64 kt outbounds centered 088^o@36 nm; Weaker WER; Conv zone at apex is decreasing in depth to 16kft MSL; 55 dBZ to 20kft MSL; Some horiz shear N of apex at low levels LLDV~30kt.; VIL down to 35 kg/m^2; MEHS < 1”.
2352 ALY	LSR#64: Wind gust to 61 in North Adams, Berkshire CO, MA

Time (UTC)	Description
2357 KENX	Bow continues but strength of deep convergence at apex going down; VIL down to 25 kg/m^2

Considerations

- Does the trainee anticipate a decreasing tornado threat with this storm as it transitions from an HP tornadic supercell to a bow echo during the first 15 minutes of this scenario?
- Does the trainee use the lightning data to notice a substantial drop in Cloud-to-Ground (CG) lightning in the comma head starting around 2230 UTC confirming a decrease in the height of the reflectivity core?
- Does the trainee use base velocity data to estimate the strength of inbound winds entering Schoharie county on the south side of the mesocyclone from 2220-2240 UTC?.
- Does the trainee use the mesocyclone and TDA product detections as the primary tool for considering storm rotation or is the base data investigated?
- Does the trainee note the warm wake (similar to an enhanced-V) signature in GOES-8 with this storm?
- Does the trainee use base data to watch the vertical extent of the cores along the flanking line convection centered at 2241 UTC?
- Does the trainee use the BGM radar to evaluate the vertical extent of this storm when it passes over the KENX RDA?
- Does the trainee note the deepening of the vertical convergence to > 13 kft MSL just south of the radar around 2306 UTC? The deep convergence zone reached up to 16 kft MSL.
- Does the trainee note the development of WERs and a strong BWER collocated with a mesocyclone and directly above the low-level gust front just southeast of the KENX radar at 2316 UTC?
- Is the trainee aware of the increasing tornadic potential of this storm by noting the mesocyclone, BWER and strong collocated low-level convergence at 2316 UTC? Also, this area is about where the gust front from the previous storm is probably located.
- Does the trainee realize this storm may be riding the old outflow boundary laid out by previous storms over an hour ago?

- Even while considering the tornado threat, does the trainee evaluate the wind and hail potential in this storm and relay this potential in the warnings.
- While considering the severe weather potential, does the trainee recognize that the trailing portion of the bow echo is traveling over a swath of heavy rainfall deposited by storms two hours ago?

Herkimer-Montgomery-Fulton-Saratoga-Schenectady-Washington-Rensselaer-Bennington-Windham County line segment

Time (UTC)	Description
2156 KBGM	VIL = 30 kg/m^2; HDA shows small hail threat only
2200 KENX	weak rotation lowest 2 tilts; VIL = 40 kg/m^2; 55 dBZ top to 21kft; MEHS = 1.0”
2202 GOES-8	IR cloud top temp (CTT) = -65°C; Cooled 3°C in 15 min. Surrounding anvil top at -61°C.
2210 KENX	>50kt inbounds in S. Herkimer CO at 3.7kft AGL; Anticyclonic rotation @311^{o}45nm; 55 dBZ top down to 18 kft
2215 GOES 8	No isolated CTT min
2220 KENX	VIL at 30 kg/m^2; MEHS < 1”; 55 dBZ down to 16 kft MSL.
2223 KBGM	VIL at 20 kg/m^2
2220-2224 ALY	LSR#38-41: Severe winds in Ft. Plain, Ames and Rural Groves in Montgomery CO., and Mohawk in Herkimer CO.
2225-2228 ALY	LSR#42-43: Severe winds in Fonda, and Charleston in Montgomery CO
2232 GOES 8	No significant CTT minima
2230 ALY	LSR#44-45: Severe winds in Gloversville, Fulton CO., and Amsterdam, Montgomery CO.
2230 KENX	Small areas of >50kt inbounds 318^o@27nm; 55 dBZ elevated core to 18 kft MSL Central Montgomery Co. Vertical convergence zone up to ~9 kft MSL just SW 308o@25nm; VIL=25 kg/m^2.
2232 GOES 8	No CTT minima; Area covered by warm wake from supercell to the SW.
2235 KENX	VIL increased to 30 kg/m^2 in new cell southeast of old one. 55dBZ to 19 kft MSL; MEHS < 1”.

Time (UTC)	Description
2245 GOES 8	CTT minima of -66^{o}C; surrounding anvil ~ -63^{o}C.
2246 KENX	Localized convergence to 40 kt up to 11kft MSL @341^{o}14nm.
2251 KENX	V inbounds decreased to 36 kt; Elevated meso V_r=35 kt, 008^o@15nm, no time continuity; 55 dBZ to 20 kft 107^o@17nm; VIL = 30 kg/m^2.
2256 KENX	V inbounds continue to decrease, cosine effect; Meso dissipated but algorithm continues to show two mesos.
2300 ALY	LSR#49: Severe winds in Duanesburg, Schenectady CO.
2301 KENX	Vert convergence/shear 12 kft MSL from E. Schenectady to S. Saratoga Co.; Multiple algorithm mesos but none show symmetry/persistence from manual obs; VIL up to 35 kg/m^2
2308 ALY	LSR#51: Severe winds in Mechanicville, Saratoga CO.
2311 KENX	36 kt V outbounds emerging behind gust front.
2315 GOES 8	CTT minima of -69^{o}C; surrounding anvil ~ -64^{o}C.
2321 KENX	50kt V outbounds emerging over S. Saratoga, NW Rensselaer COs; Z/SRM structure unchanged with many spurious meso detections along gust front (due to viewing angle).
2327 KENX	Multiple 50kt V outbounds Rensselaer, S. Washington COs;
2332 GOES 8	No distinct CTT minima
2335 ALY	LSR#59: Severe winds in Greenwich, Washington CO. (late?).
2337 KENX	50kt outbound area SW Bennington CO - NE Rensselaer CO. Small area of >64kt outbounds embedded.
2352 KENX	North end of line merging with lead cell. Convergence zone ~12 kft MSL.
2355 ALY	LSR#63: Severe winds at Brattleboro, Windham CO, VT (not confident of this report timing).

Considerations

- Does the trainee note the >50kt radial inbound winds early on in Herkimer County?
- Does the trainee require the severe wind reports to initiate a warning? If so, is the reasoning valid (i.e. did not expect winds to reach ground in stabilized airmass)?

- Does the trainee have an informed opinion on the performance of the algorithms, in this case, the Hail Detection algorithm based on current reports up to 2230 UTC?
- Does the trainee note the reduction in inbounds on the base velocity when the squall line begins to pass north of KENX around 2251 UTC due to the cosine effect of radial velocity?
- Does the trainee note and discount the multiple mesocyclone detections as the squall line is north of the radar after 2250 UTC as being a consequence of viewing shear along a gust front interface? None of these detections would be likely if a different viewing angle was employed.
- Does the trainee note the emergence of high outbounds behind the line after the line passes well off to the east after 2320 UTC?
- Does the trainee note that the northern part of the squall line is passing over a swath of heavy rainfall previously laid out by other storms?
- Does the trainee consider the validity of the rainfall laid out by the previous storms?

Lewis - Herkimer County storm

Time (UTC)	Description
2223 KBGM	VIL = 45 kg/m^2
2225 KENX	55 dBZ at 21 kft MSL
2228 KBGM	VIL decreased to 35 kg/m^2;

Considerations

As this storm is approaching the northwest corner of the CWA, Is the trainee aware of its existence and the threat it poses before it reaches the CWA border?

Rensselaer-far SE Washington- Bennington-Windham County storm

Time (UTC)	Description
2225 KENX	VIL = 25 kg/m^2,55 dBZ to 12 kft. MEHS < 1”
2230 KENX	VIL increased to 30 kg/m^2 in far NE Albany Co.; MEHS < 1”
2232 GOES-8	No discernible CTT minima; Large anvil canopy ovhd.

Time (UTC)	Description
2241 KENX	VIL up to 40 kg/m^2; 55dBZ to 20 kft MSL; Elevated 65 dBZ core 16 kft MSL.
2245 GOES-8	CTT min -65^{o}C poorly defined.
2251 KENX	VIL up to 40 kg/m^2; 55 dBZ to 21 kft MSL; Dealiasing probs at 0.5° slice; Weak cycl (anticycl) shear couplet
2256 KENX	TDA detected TVS with 90kt LLDV; 0.5^o velocity couplet too close to range folding to trust the detection. No meso, No WER or BWER; 55dBZ to 23kft with elevated core to 65dBZ
2301 KENX	TDA lost detection; Still TVS shear a 1.5^o but no vert continuity; Weak cycl circulation in deeper layer; VIL up to 50 kg/m^2; 55 dBZ to 26 kft; MEHS=1.75”
2311 KENX	elevated meso V_r=30kt 64^o@39nm; 55 dBZ to 27 kft; VIL = 55 kg/m^2.
2312-2315 ALY	LSR#53-54: 1.75” hail in White Creek, far SE Washington CO., and Shaftsbury, Bennington CO. VT.
2315 GOES 8	CTT minimum=-68^{o}C; Surrounding anvil=-64^{o}C; weak warm wake
2321 KENX	WER 066^o@48nm; 55 dBZ down to 23kft MSL.;VIL down to 35kg/m^2; MEHS = 1”.
2326 KENX	WER weakened; 55 dBZ down to 17 kft MSL; VIL down to 25kg/m^2. MEHS below 1”.
2332 GOES 8	CTT minimum=-67^{o}C; Weak warm wake
2337 KENX	VIL up to 35 kg/m^2; MEHS <1”
2342 KENX	TDA found a TVS in Windham Co., VT; Manual obs do not con-cur; Circulation/weak meso found with V_r~30 kt; Weak WER near circulation; VIL up to 40 kg/m^2;
2345 GOES 8	No distinct CTT minima; Cell anvil overtaken by top from squall line just to the west.
2347 KENX	TDA lost TVS; No TVS and very weak circulation V_r<30kt; No more WER; 55 dBZ only to 15 kft MSL;
2352 KENX	TVS with LLDV 90kt; No TDA detection; Due to distance, most likely meso; However, weak WER overlays LLDV and cell is merging with squall line.
2357 KENX	Lost TVS but shallow meso continues V_r~40kts; 55dBZ to 24 kft MSL.

Considerations

- When does the trainee begin to consider this cell for warning?
- Does the trainee notice the TVS detected by the TDA at 2256 UTC?
- How does the trainee react to the existence of this feature? Some of the shear might be questionable due to proximity to range folding. The TVS is not manually confirmed. There is also little supporting evidence of a very strong updraft.
- How does the trainee evaluate hail size potential?
- What hail size does the trainee consider to be possible with this storm around 2311 UTC?
- Does the trainee notice the rapid increase in LTGCG around 2306 UTC?
- Does the trainee reasonably evaluate the wind potential in this storm? The cell is passing over a stabilized boundary layer.
- Does the trainee notice the decrease in LTGCG around 2342 UTC?
- How does the trainee react to the various gate-to-gate shears in the lowest few slices of the SRM data from 2342 - 2352 UTC? Some of these might be real since there is also a background weak circulation. However, distance may mean these are just well-sampled mesocyclone circulations. No supporting WER, BWER, and a stable surface environment are negative factors for tornado potential.

9: Virtual Reality Simulation (Geographic Threat)

I. Introduction

This simulation focuses on the unique aspects of handling warning responsibility for a CWA containing numerous storms, one of which produces significant tornadoes (F2 damage), and others that contain tornado, severe wind and hail potential. In addition, several storms pass over heavy rainfall swaths laid down by previous storms in the previous two hours requiring flash flood warning consideration. Contrasting the virtual reality simulation of the first period (2005-2205 UTC), this simulation asks the trainee to consider all warning types in a geographic sector. This simulation is appropriate for an experienced warning forecaster who is proficient with the mechanics of issuing warnings and can benefit from practicing warning workload management.

Objective

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Trainer Evaluation Guide), and V (Post-simulation Briefing) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Interrogate all severe weather threats for a sector in the northern half of the CWA, and issue warnings and follow up statements.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and document trainee briefing, and discuss sectorizing issues for this event.

Simulation: Manage the simulation, evaluate the performance of the trainee, and interject information such as spotter reports, special forecast requests, and any type of challenges that can happen in a real event (be creative!).

Post-Brief: Discuss trainee performance and any lessons learned from the simulation and how they can be implemented at the local office.

This virtual reality simulation is designed to take 3 hours to complete, with 30 minutes for the pre-simulation briefing, 2 hours for the simulation, and 30 minutes for the post-brief. The simulation starts at 2200 UTC on May 31st, 1998 and ends at 0000 UTC on June 1st, 1998. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-2 on page C-3) for discussing warning sector issues.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 2200 UTC on May 31st, 1998 to 0000 UTC on June 1st, 1998.

4. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

5. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the ALY CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

6. Instruct the trainee to:

- Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA.
- Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.
- Evaluate warning sectorization issues.

7. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

- 0-6 km shear 50 kts and BRN shear > 40 is supportive of supercell storms.
- Anvil-level SR flow (40 kts) suggests wet-end of classic supercells given isolated initiation.
- Low-level (0-3 km) shear is very strong (40 kts), higher just north of outflow boundary, enhancing supercell tornado potential. The 0-1 km shear has likely been increased the most just north of this boundary.
- Midlevel SR flow for right-moving supercells is 20 kts which is favorable for tornadoes.
- Morning soundings indicates a layer of dry air and steep lapse rates suggestive of an Elevated Mixed Layer (EML) at Pittsburgh. The buffalo soundings do not show an EML but also there is a much lower cap. The Albany sounding shows elevated moisture surging over a warm frontal boundary.
- Surface dewpoint depressions 15° F or less allow for favorably low LCLs for tornadoes assuming surface dewpoints are well mixed in the boundary layer.

- Midlevel lapse rates are not indicated to be steep and the lack of analyzed midlevel dry air results in theta-E differences < 30° K from the surface to 600 mb. Wet microburst potential is generally low. However, highest potential would be in southern zones with access to dry midlevel air with steep lapse rates evident in the PBZ 12 UTC Skew-T.
- Large hail potential is significant given 20 kt storm-relative midlevel flow, strong shear and high CAPEs. Wet Bulb Zero (WBZ) values (~10.5-11 kft MSL) just above the optimal layer for greatest severe hail threat. Therefore, large hail potential is greatest for supercell storms, and limited for nonsupercells.
- The first wave of severe weather exited CWA leaving an outflow boundary across Northern Greene and Southern Rensselaer counties.
- Isolated supercells and short, severe wind producing line segments to the west of the CWA, plus reports of tornadoes out in Binghamton suggest atmosphere is capable of extreme severe weather. The mix of observed storm types suggests a full range of severe weather is possible in the next two hours in this CWA.
- Short-duration, heavy rain potential heightened due to storms realizing the high CAPE, and deep moisture. Rapid storm motion will minimize prolonged heavy rainfall. “Corfidi” vector motion is 20 kts suggesting that if a MCC does form, prolonged heavy rain potential is not likely.
- The 850 mb winds are strong suggesting rapid airmass recovery is possible behind initial cells.
- LAPS cannot analyze position of outflow boundary owing to the lack of METAR observations.
- In addition, high midlevel lapse rates are likely residing in the southern half of the CWA. LAPS is not depicting these lapse rates.

8. Make sure the trainee is comparing direct observations with any LAPS, or other diagnostic model output.

9. Inform the trainee that the flash flood guidance for the ALY CWA is approximately 2” for one hour, and 3” for three hours.

10. Point out on the SPC products provided in Appendix B that the CWA is in a high risk area, and a tornado watch has been issued with a threat for tornadoes, hail to 2 inches in diameter, and wind gusts to 70 kts.

III. Simulation

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. This 2 hour simulation starts at 2200 UTC on May 31st, 1998, and ends at 0000 UTC on June 1st, 1998. For a storm-by-storm breakdown of important features in the data and important evaluation points, consult the Trainer Evaluation Guide on page 9-8.

Trainer Tasks

1. State to the trainee:
   - The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products.
   - The trainee will be responsible for interrogating all severe weather threats, creating warnings, and issuing follow on statements.
   - There will be no pauses during the 2 hour simulation (plan accordingly).
   - The trainee should communicate any sectorizing issues/confusion with the trainer during the event.
   - The trainer will be forwarding spotter reports to the trainee during the simulation.

2. Close down any existing D2D sessions, and start the simulation for the time period 2200 UTC on May 31st, 1998 to 0000 UTC on June 1st, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

3. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:
   - In the text editor, click under “File”, “Export to File...”.
   - Type in the name of the warning at the end of the path in the “filename” box on the bottom of the popup window and click OK.

4. Give the trainee 5-10 minutes to set up their D2D sessions.

5. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide on page 9-8 (consult image in Appendix A for graphical locations), and make up conflicting spotter reports during the simulation to determine if the trainee is evaluating the reports well. Any other incoming calls or distractions should be interjected as to simulate a real environment. This could include briefings to EMS, toxic spills, failure for a warning to transmit, etc.

6. At 2220 UTC consider giving a distracting request. The NY state DOT called requesting a weather update for a multi-car auto pileup on I-88 near Richmondville in the next few hours. Evaluate the trainee's ability to effectively answer the request in a timely manner, including whether the response mentions all potential severe weather threats.

7. At 2235 UTC consider giving a distracting request. The Rensselaer County EM calls and says he hears thunder to the southwest. He's wondering how bad it's going to get because he's coordinating emergency operations in the area of the tornado damage in Mechanicville. Evaluate the trainee's ability to respond to the request in a timely manner and how the trainee responds to the information.

8. At 2251 UTC consider giving a leading report. A sheriff in Rotterdam (Schenectady CO.) reports seeing multiple lowerings to the west. Evaluate the trainee's ability to assimilate this information and weigh it in context of storm structure and near storm environment.

9. At 2306 UTC consider disrupting the warning operations. Simulate a D2D crash or spontaneous logout. ***Do not stop the simulator.*** Either have the trainee exit and restart D2D, or have the trainee stop using D2D temporarily and explain how they would recover. Evaluate the trainee's ability to recover from the disruption.

10. At 2308 UTC consider giving a distracting request. The city of Bennington EM calls with reports that some small streams seem pretty high. He wants to know what the flash flood threat is for the Hoosic river which passes through his town. Evaluate the trainee's ability to respond to his request, especially if a computer crash has just occurred.

11. At 2337 UTC consider giving a distracting request. The owner of the Lake George Islands campground heard that a funnel cloud was spotted west of Warrensburg (Warren CO.). He would like to know if it's a good idea to evacuate the grounds. Evaluate the trainee's ability to effectively answer the request in a timely manner.

IV. Post-simulation Briefing

The objective of the post simulation briefing is to summarize the successes and failures of the warning process and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation done during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- Handling stress and workload so as to keep the effective flow of information going.
- Off-loading tasks as necessary.
- Maintaining the big picture issues while periodically focussing on the details.
- Maintaining a high level of situation awareness throughout.
- Recognizing rapidly evolving signatures leading to potential severe weather.
- Analyzing the potential for flash flooding in a situation where numerous severe thunderstorms are occurring.
- Optimal sectorization.

Trainer Tasks

1. Ask the trainee to:
   - Discuss challenges in managing the warning workload.
   - Discuss any problems encountered with responding to the disruptions in the warning environment.

2. Review the reports and the times to compare to the warnings.

3. Discuss the lessons learned from the event, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. The evaluation of the trainee by the trainer is to be done while the trainee is actively involved in the warning operations. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation.

General Issues

Time (UTC)	Description
1801-0557 KBGM	radar data time period (limited radar products)
2002-0034 KENX	radar data time period (full set of radar products)
2156-2223 KBGM	radar data unavailable
2234-2250 KBGM	radar data unavailable

Considerations

- Does the trainee anticipate the areas of highest expected threat of severe weather based on the position of the gust front laid out by storms in the previous two hours, strong values of 0-3 km SRH/shear, high SBCAPE south of the boundary, lower CAPE north of the boundary.
- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?
- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?
- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, and LAPS)?

- Does the trainee recognize that LAPS cannot adequately analyze surface fields within the Catskill or Berkshire mountains owing to the lack of surface data?
- Does the trainee analyze where the outflow boundary in the correct position so that the proper adjustments can be made to the LAPS near-surface temperature, dewpoint and instability fields?
- Does the trainee use the VWP products from KBGM and KENX to compare with the wind fields analyzed by LAPS?
- Does the trainee also use the VWP products to estimate the depth of the outflow boundary left over from the previous convection? And that strong 850 mb winds are providing lift over the outflow boundary?

Storm Summary

During this part of the simulation, second round of severe thunderstorms crossed the ALY CWA. A thunderstorm outflow boundary, which has been left behind the first wave of convection, has settled southward to an east-west line near the Greene, Albany county border. However, its exact position within the complicated terrain of Eastern New York is unable to be determined. Very strong low-level and deep layered shear continues across the area, however surface-based instability has been significantly reduced north of the outflow boundary. Three areas of storms cross the sector of the CWA identified for this simulation.

The most significant cluster of convection needing attention includes an HP supercell, with a history of large tornadoes, which rapidly evolves into a bow echo as it enters the CWA in Schoharie and Albany counties. The bow echo weakens and a new updraft grows on the surging outflow boundary leading to a new severe bow echo across Southern Albany into Southern Rensselaer counties, likely following the outflow boundary. An updraft responsible for the new bow developed rotation and a BWER just before an F2 tornado touched down in Southern Rensselaer county. This bow quickly moved east into Massachusetts with just a few wind damage reports.

A squall line segment extending northeast of the bow echo complex was not impressive from a storm structure standpoint, however it supported an organized Rear Inflow Jet (RIJ) structure and the gust front remained fairly close to the leading edge of the core. Base velocity measurements within the RIJ suggested severe winds are likely as the RIJ mixes high momentum air downward to the surface. Several severe wind reports from Montgomery to Fulton county supported the radar observations. More high wind reports ensued as the squall line segment passed east into Schenectady, Saratoga, Bennington and Northern Rensselaer counties.

Several cells east of the squall line segment developed over the cold dome became severe. The most significant cell developed in Northern Albany county early in this period and moved into Northern Rensselaer, and Southern Bennington County, Vermont before merging with the squall line segment moving in Windham County. This storm produced occasional periods of rotation, WERs and high reflectivities at high altitudes. Reports of golf ball-sized hail confirmed the hail potential of this one cell.

Flash flooding was also a concern. Earlier convection laid down two paths of > 1” of rainfall, one on either side of the KENX RDA. The large HP supercell to bow echo complex moved added rainfall to both these paths, especially the one south of the RDA. A short period of echo training along the trailing gust front produced 2-3” of additional rainfall within one hour in Northern Greene County with another in Central Schoharie County. This rainfall track runs into Southern Rensselaer county. Another rainfall track of greater than 2.5” runs through Northern Rensselaer into Bennington County, Vermont. Both of these tracks likely are exaggerated from hail contamination. In addition, no significant flooding was reported anywhere in the Albany CWA.

Otsego-Schoharie - Albany - Rensselaer - Berkshire County Storm

Time (UTC)	Description
2156 KBGM	Meso V_r=45kt @054°38nm; no alg TVS but LLDV>70kt; VIL=60kg/m^2; MEHS=1.5”
2200 KENX	TVS>76 kt LLDV 269°53nm; Thick hook with BWER above; VIL=65 kg/m^2; MEHS=2”.
2200 BGM	LSR#18: Tornado reported near North Norwich, Chenango CO (likely very late report with this storm)
2205 KENX	TVS > 65 kt LLDV 270^{o}50nm; new meso firming up to the SE
2202 GOES-8	IR minimum cloud top temp -71°C; surrounding anvil=-63°C. EV
2210 KENX	TVS>66 kt LLDV @271°47nm; New large meso; hook encircled meso; doughnut hole 10kft MSL; VIL> 70 kg/m^2; MEHS=1.5”.

Time (UTC)	Description
2215 KENX	TVS in new meso intensified with LLDV > 95kt; Double meso structure with TVS in new one to east; Core is wrapping around meso; VIL down to 55 kg/m^2 POSH>70&% MEHS = 2” KOAX MEHS = 1.25”; RFD igniting convection to the SE
2215 GOES 8	CTT min up to -68^{o}C; EV still apparent
2220 KENX	TVS dissipated; strong meso; Core wrapped around meso and RFD has ignited convection; VIL sharply down to 35 kg/m^2; MEHS below 1”; Large area of >64 kt inbounds in RFD
2225 KENX	New cell in S. Schoharie Co. ahead of bowing RFD segment has 55dBZ to 24 kft. Meso now a comma head with deeper cells along RFD to the south. No TVS
2225 LTGCG	5 minute LTGCG decreases rapidly in comma head area
2230 GOES 8	Lost CTT min over meso. New CTT min -71^{o}C with new lead cell in S. Schoharie Co.
2230 KENX	Area of >64 kt inbounds entering Schoharie with RFD.
2225-2230 BGM	LSR#24: tornado Portlandville-Maryland, Otsego CO.
2232 GOES-8	CTT min=-71^{o}C over lead cell; Double warm wake, one over comma head, second developed over flanking line cell.
2235 KENX	Multiple meso detections along old RFD. Also strong anticy-clonic rotation on S side of rear inflow notch; 55 dBZ to 24 kft on flanking line; VIL up to 50 kg/m^2; MEHS up to 1.25”.
2230-2235 BGM	LSR#29: tornado with major forest damage from Laurens to Mil-ford, Otsego CO. House damage reported too. This report is likely 15-20 minutes late.
2235 ALY	LSR#46: Severe wind reported in Richmondville, Schoharie CO.
2241 KENX	Comma head still producing >64kt inbounds @273^o 20nm. Flanking line core stronger; 55dBZ to 36kft @ 250^o 27nm; VIL up to 65 kg/m^2.
2245 GOES-8	CTT min = -69^{o}C with EV over Schoharie Co. CTT = -68^{o}C over Albany CO too.
2247 ALY	LSR#47-48: 0.75” hail North Blenheim, and severe wind in Breakabeen, Schoharie CO.
2250 KBGM	VIL down to 30 kg/m^2. Overly large meso detection is elevated.

Time (UTC)	Description
2251 KENX	0.5^o Vel inbounds down to 50kt E. Schoharie Co. 960' AGL. Multiple meso detections along gust front, all elevated/shallow; VIL down to 40 kg/m^2, in Schoharie Co. MEHS to 1".
2300 KBGM	VIL up to 30 kg/m^2 but MEHS < 1"
2301 KENX	Core over radar; VIL cut down by cone of silence; Convergence over 11 kft deep 8-10 mi S. of RDA;
2306 KENX	>64kt outbound 135^o@4nm Deep vertical conv zone to 13 kft S of max outbound; Conv increasing; VIL truncated by cone;
2310 KBGM	VIL up to 50 kg/m^2; MEHS = 1"
2311 KENX	Meso in SRM 104^o@9nm above 0.5^o refl inflow notch; WERs or BWERs along leading edge of core 100^o@10nm to 130^o@13nm; Expanding > 64kt outbounds centered 116^o@8nm
2308-2311 ALY	LSR#50&52: Severe winds Clarksville, New Scotland, Albany CO just SW of Albany.
2315 KBGM	VIL down to 40 kg/m^2; MEHS = 1.0"
2315 GOES 8	CTT minima -71^{o}C; Warm wake
2316 KENX	Area >64kt outbounds at 105^o@12nm; Strong BWER 087^o@13nm; Meso V_r~'40 kt associated; rear notch to the south; VIL coming up with better sampling
2321 KENX	Meso V_r=45 kts 090^o@17nm; BWER starts ~ 6kft MSL.; 55dBZ to 29kft; Storm emerging from cone of silence; VIL=45kg/m^2; MEHS=1.5"
2326 KENX	LLDV 50kt, almost TVS 091^o@20nm; Meso with V_r=40kt ovhd; Still deep conv zone to 20kft MSL south of TVS; BWER weakened still larger WER with meso; 55dBZ to 25 kft MSL.
2331 KENX	Large >64 kt outbounds centered 090^o@25nm; Another >64kt outbound centered 119^o@19nm; BWER dissipated; Large rear inflow notch; 55 dBZ to 28 kft MSL; VIL up to 55 kg/m^2; MEHS = 1.25".
2332 GOES 8	Lost CTT minima but warm wake continues
2322-2332 ALY	LSR#55: Tornado (late report), 1.5 NNW East Shodack to 3.4 ENE Millers Corners, S. Rensselaer CO.
2337 KENX	New WERs at apex of bow; No more meso, or asymmetrical; Deep conv zone continues at bow apex; 55dBZ to 24 kft MSL; VIL at 45 kg/m^2; MEHS=1.5".

Time (UTC)	Description
2330-2337 ALY	LSR#56-58: Severe winds at New Scotland, Albany CO., Greenville, N. Greene CO., and Schoharie in Schoharie CO. (likely late report)
2340 ALY	LSR#60: Severe winds in New Baltimore, far NE Greene CO.
2342 KENX	WER is shallower at apex of bow otherwise no major changes
2342 ALY	LSR#61: 0.75” hail Stephentown, SE Rensselaer CO.
2345 GOES 8	No CTT minima and warm wake lost definition
2347 KENX	Large > 64 kt outbounds centered 088^o@36 nm; Weaker WER; Conv zone at apex is decreasing in depth to 16kft MSL; 55 dBZ to 20kft MSL; Some horiz shear N of apex at low levels LLDV~30kt.; VIL down to 35 kg/m^2; MEHS < 1”.
2352 ALY	LSR#64: Wind gust to 61 in North Adams, Berkshire CO, MA
2357 KENX	Bow continues but strength of deep convergence at apex going down; VIL down to 25 kg/m^2

Considerations

- Does the trainee anticipate a decreasing tornado threat with this storm as it transitions from an HP tornadic supercell to a bow echo during the first 15 minutes of this scenario?
- Does the trainee use the lightning data to notice a substantial drop in Cloud-to-Ground (CG) lightning in the comma head starting around 2230 UTC confirming a decrease in the height of the reflectivity core?
- Does the trainee use base velocity data to estimate the strength of inbound winds entering Schoharie county on the south side of the mesocyclone from 2220-2240 UTC?.
- Does the trainee use the mesocyclone and TDA product detections as the primary tool for considering storm rotation or is the base data investigated?
- Does the trainee note the warm wake (similar to an enhanced-V) signature in GOES-8 with this storm?
- Does the trainee use base data to watch the vertical extent of the cores along the flanking line convection centered at 2241 UTC?
- Does the trainee use the BGM radar to evaluate the vertical extent of this storm when it passes over the KENX RDA?

- Does the trainee note the deepening of the vertical convergence to > 13 kft MSL just south of the radar around 2306 UTC? The deep convergence zone reached up to 16 kft MSL.
- Does the trainee note the development of WERs and a strong BWER collocated with a mesocyclone and directly above the low-level gust front just southeast of the KENX radar at 2316 UTC?
- Is the trainee aware of the increasing tornadic potential of this storm by noting the mesocyclone, BWER and strong collocated low-level convergence at 2316 UTC? Also, this area is about where the gust front from the previous storm is probably located.
- Does the trainee realize this storm may be riding the old outflow boundary laid out by previous storms over an hour ago?
- Even while considering the tornado threat, does the trainee evaluate the wind and hail potential in this storm and relay this potential in the warnings.
- While considering the severe weather potential, does the trainee recognize that the trailing portion of the bow echo is traveling over a swath of heavy rainfall deposited by storms two hours ago?

Herkimer-Montgomery-Fulton-Saratoga-Schenectady-Washington-Rensselaer-Bennington-Windham County line segment

Time (UTC)	Description
2156 KBGM	VIL = 30 kg/m^2; HDA shows small hail threat only
2200 KENX	weak rotation lowest 2 tilts; VIL = 40 kg/m^2; 55 dBZ top to 21kft; MEHS = 1.0”
2202 GOES-8	IR cloud top temp (CTT) = -65°C; Cooled 3°C in 15 min. Surrounding anvil top at -61°C.
2210 KENX	>50kt inbounds in S. Herkimer CO at 3.7kft AGL; Anticyclonic rotation @311^{o}45nm; 55 dBZ top down to 18 kft
2215 GOES 8	No isolated CTT min
2220 KENX	VIL at 30 kg/m^2; MEHS < 1”; 55 dBZ down to 16 kft MSL.
2223 KBGM	VIL at 20 kg/m^2
2220-2224 ALY	LSR#38-41: Severe winds in Ft. Plain, Ames and Rural Groves in Montgomery CO., and Mohawk in Herkimer CO.

Time (UTC)	Description
2225-2228 ALY	LSR#42-43: Severe winds in Fonda, and Charleston in Montgomery CO
2232 GOES 8	No significant CTT minima
2230 ALY	LSR#44-45: Severe winds in Gloversville, Fulton CO., and Amsterdam, Montgomery CO.
2230 KENX	Small areas of >50kt inbounds 318^o@27nm; 55 dBZ elevated core to 18 kft MSL Central Montgomery Co. Vertical convergence zone up to ~9 kft MSL just SW 308o@25nm; VIL=25 kg/m^2.
2232 GOES 8	No CTT minima; Area covered by warm wake from supercell to the SW.
2235 KENX	VIL increased to 30 kg/m^2 in new cell southeast of old one. 55dBZ to 19 kft MSL; MEHS < 1”.
2245 GOES 8	CTT minima of -66^{o}C; surrounding anvil ~ -63^{o}C.
2246 KENX	Localized convergence to 40 kt up to 11kft MSL @341^{o}14nm.
2251 KENX	V inbounds decreased to 36 kt; Elevated meso V_r=35 kt, 008^o@15nm, no time continuity; 55 dBZ to 20 kft 107^o@17nm; VIL = 30 kg/m^2.
2256 KENX	V inbounds continue to decrease, cosine effect; Meso dissipated but algorithm continues to show two mesos.
2300 ALY	LSR#49: Severe winds in Duanesburg, Schenectady CO.
2301 KENX	Vert convergence/shear 12 kft MSL from E. Schenectady to S. Saratoga Co.; Multiple algorithm mesos but none show symmetry/persistence from manual obs; VIL up to 35 kg/m^2
2308 ALY	LSR#51: Severe winds in Mechanicville, Saratoga CO.
2311 KENX	36 kt V outbounds emerging behind gust front.
2315 GOES 8	CTT minima of -69^{o}C; surrounding anvil ~ -64^{o}C.
2321 KENX	50kt V outbounds emerging over S. Saratoga, NW Rensselaer COs; Z/SRM structure unchanged with many spurious meso detections along gust front (due to viewing angle).
2327 KENX	Multiple 50kt V outbounds Rensselaer, S. Washington COs;
2332 GOES 8	No distinct CTT minima
2335 ALY	LSR#59: Severe winds in Greenwich, Washington CO. (late?).

Time (UTC)	Description
2337 KENX	50kt outbound area SW Bennington CO - NE Rensselaer CO. Small area of >64kt outbounds embedded.
2352 KENX	North end of line merging with lead cell. Convergence zone ~12 kft MSL.
2355 ALY	LSR#63: Severe winds at Brattleboro, Windham CO, VT (not confident of this report timing).

Considerations

- Does the trainee note the >50kt radial inbound winds early on in Herkimer County?
- Does the trainee require the severe wind reports to initiate a warning? If so, is the reasoning valid (i.e. did not expect winds to reach ground in stabilized airmass)?
- Does the trainee have an informed opinion on the performance of the algorithms, in this case, the Hail Detection algorithm based on current reports up to 2230?
- Does the trainee note the reduction in inbounds on the base velocity when the squall line begins to pass north of KENX around 2251 due to the cosine effect of radial velocity?
- Does the trainee note and discount the multiple mesocyclone detections as the squall line is north of the radar after 2250 as being a consequence of viewing shear along a gust front interface? None of these detections would be likely if a different viewing angle was employed.
- Does the trainee note the emergence of high outbounds behind the line after the line passes well off to the east after 2320 UTC?
- Does the trainee note that the northern part of the squall line is passing over a swath of heavy rainfall previously laid out by other storms?
- Does the trainee consider the validity of the rainfall laid out by the previous storms?

Lewis - Herkimer County storm

Time (UTC)	Description
2223 KBGM	VIL = 45 kg/m^2

Time (UTC)	Description
2225 KENX	55 dBZ at 21 kft MSL
2228 KBGM	VIL decreased to 35 kg/m^2;

Considerations

As this storm is approaching the northwest corner of the CWA, Is the trainee aware of its existence and the threat it poses before it reaches the CWA border?

Rensselaer-far SE Washington- Bennington-Windham County storm

Time (UTC)	Description
2225 KENX	VIL = 25 kg/m^2,55 dBZ to 12 kft. MEHS < 1”
2230 KENX	VIL increased to 30 kg/m^2 in far NE Albany Co.; MEHS < 1”
2232 GOES-8	No discernible CTT minima; Large anvil canopy ovhd.
2241 KENX	VIL up to 40 kg/m^2; 55dBZ to 20 kft MSL; Elevated 65 dBZ core 16 kft MSL.
2245 GOES-8	CTT min -65^{o}C poorly defined.
2251 KENX	VIL up to 40 kg/m^2; 55 dBZ to 21 kft MSL; Dealiasing probs at 0.5o slice; Weak cycl (anticycl) shear couplet
2256 KENX	TDA detected TVS with 90kt LLDV; 0.5^o velocity couplet too close to range folding to trust the detection. **No** meso, **No** WER or BWER; 55dBZ to 23kft with elevated core to 65dBZ
2301 KENX	TDA lost detection; Still TVS shear a 1.5^o but no vert continuity; Weak cycl circulation in deeper layer; VIL up to 50 kg/m^2; 55 dBZ to 26 kft; MEHS=1.75”
2311 KENX	elevated meso V_r=30kt 64^o@39nm; 55 dBZ to 27 kft; VIL = 55 kg/m^2.
2312-2315 ALY	LSR#53-54: 1.75” hail in White Creek, far SE Washington CO., and Shaftsbury, Bennington CO. VT.
2315 GOES 8	CTT minimum=-68^{o}C; Surrounding anvil=-64^{o}C; weak warm wake
2321 KENX	WER 066^o@48nm; 55 dBZ down to 23kft MSL.;VIL down to 35kg/m^2; MEHS = 1”.

Time (UTC)	Description
2326 KENX	WER weakened; 55 dBZ down to 17 kft MSL; VIL down to 25kg/m^2. MEHS below 1”.
2332 GOES 8	CTT minimum=-67^{o}C; Weak warm wake
2337 KENX	VIL up to 35 kg/m^2; MEHS <1”
2342 KENX	TDA found a TVS in Windham Co., VT; Manual obs do not concur; Circulation/weak meso found with V_r~30 kt; Weak WER near circulation; VIL up to 40 kg/m^2;
2345 GOES 8	No distinct CTT minima; Cell anvil overtaken by top from squall line just to the west.
2347 KENX	TDA lost TVS; No TVS and very weak circulation V_r<30kt; No more WER; 55 dBZ only to 15 kft MSL;
2352 KENX	TVS with LLDV 90kt; No TDA detection; Due to distance, most likely meso; However, weak WER overlays LLDV and cell is merging with squall line.
2357 KENX	Lost TVS but shallow meso continues V_r~40kts; 55dBZ to 24 kft MSL;

Considerations

- When does the trainee begin to consider this cell for warning?
- Does the trainee notice the TVS detected by the TDA at 2256 UTC?
- How does the trainee react to the existence of this feature? Some of the shear might be questionable due to proximity to range folding. The TVS is not manually confirmed. There is also little supporting evidence of a very strong updraft.
- How does the trainee evaluate hail size potential?
- What hail size does the trainee consider to be possible with this storm around 2311 UTC?
- Does the trainee notice the rapid increase in LTGCG around 2306 UTC?
- Does the trainee reasonably evaluate the wind potential in this storm? The cell is passing over a stabilized boundary layer.
- Does the trainee notice the decrease in LTGCG around 2342 UTC?
- How does the trainee react to the various TVS shears from 2342 - 2352 UTC? Some of these might be real since there is also a background weak circulation. However, distance may mean these are just well-sampled

mesocyclone circulations. No supporting WER, BWER and cool surface environment work against tornado potential.

10: Case Study Simulation

I. Introduction

In this exercise, D2D will be used to review data which covers an 8 hour period from 1200 UTC to 2007 UTC on May 31st, 1998. Climatology, synoptic-scale processes, then mesoscale processes will be considered sequentially to provide a multi-scale analysis related to the warning process. Following this analysis, the trainee may wish to proceed on to any of the warning simulation examples included with the Simulation Guide.

Objectives

The training objectives of this case study simulation are to:

- To provide a learning aid for operational meteorologists in analyzing and assessing the pre-storm convective storm environment. In this case study simulation mode, the goal of the analysis process is the development of a Hazardous Weather Outlook (HWO: http://www.srh.noaa.gov/jan/hwo_info.htm). The particular HWO product for this case study simulation is intended to describe a 0 to 12 hr forecast for the period from 12 to 00 UTC of expected severe weather across the County Warning Area (CWA), which, for this simulation, is Albany, NY (ALY).
- After the analysis process, the trainee is expected to answer a short series of questions to help evaluate understanding of some of the concepts that are exemplified in the forecast process described in the guide. By completing these training activities, the trainee can improve skill levels in analyzing and assessing the pre-storm convective environment. Using this simulation guide can also help prepare the trainee to improve performance during other simulation modes.

The local training officer may wish to run through the case study in its current form, or use this example to create their own case study with different learning objectives.

Responsibilities

Support materials in sections I (Introduction), II (Environment Analysis), and III (Summary) have been designed for a two person training session with the following responsibilities:

Trainee

- The trainee will be asked to incorporate a forecast funnel approach (similar to steps outlined in the Severe Convection Professional Development Series - available at http://www.wdtb.noaa.gov/resources/PDS/newconvectpds.htm) in order to analyze and synthesize the data from 1200 to 1845 UTC on 31 May 1998 into a forecast of expected severe weather for the 1800 to 0000 UTC time period. In particular, the approach will mirror the job task skills in PCU 2, 3 and 4 (climatology, synoptic and mesoscale assessment). The trainee should first analyze the synoptic scale environment, from 1200 -1800 UTC and make a forecast in the format of a Hazardous Weather Outlook (HWO) of the relative likelihood of general severe weather based on that assessment. Then, the trainee should proceed with a mesoscale analysis from 1845-2000 UTC to modify (if needed) and further specify the expectations of the perceived severe weather threat. The 2007 UTC updated forecast should be in the form of a shift change briefing.

Trainer

- Review of the HWO text will allow the trainer a way to gauge how well the trainee can synthesize the data and formulate into a forecast product. Since forecasting is a highly subjective process, evaluation of how well the trainee analyzes the environment on the synoptic scale and mesoscale is difficult. However, the practicing of a prescribed methodology based on certain job task skills defined in the severe convection PDS may help forecasters, especially novice ones, to develop and hone certain skills that are important in performing this stage of the integrated warning process. For a means of objective evaluation, the trainer will have a series of questions to present to the trainee on particular aspects of the event and the forecast process employed. Evaluating the trainee's answers to these questions will provide an excellent opportunity to review some important conceptual understanding of severe weather evolution and possibly offer the trainee some further training options (teletraining, web sites, etc.). Upon completion of this simulation, the trainer may wish to have the trainee proceed to one of the other simulation types in this WES simulation guide.

This case study simulation is designed to take 3.25 hours to complete. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

A. Climatology (optional)

The suggested completion time for the Climatology assessment is 20 minutes.

The objective of the climatology analysis is to become familiar with the relative frequency of severe weather on May 31st for the ALY CWA. NSSL's online severe weather climatology module will be used as the analysis tool to evaluate severe weather climatology. This module uses the Storm Data database and the Tom Grazulis Tornado Project database to create heavily smoothed time and space plots of severe weather frequency in the continental US. Details of the analysis techniques are included with the online module that is loaded in this section. The trainee and trainer will need to use a PC connected to the internet to work through the exercise. This web-based climatology analysis can be easily applied to other CWA's, and it can be incorporated into any existing local climatology.

Trainer Tasks

1. On a PC connected to the internet, have the trainee analyze the following website:

http://www.nssl.noaa.gov/hazard/

2. Ask the trainee to analyze how the calendar date May 31st relates to the average severe weather season for tornadoes, hail, and wind. To do this task, have the trainee generate a time series for each severe event type for the ALY CWA by selecting the annual cycles button and

then for the appropriate event type, click on east-central New York to obtain plots relevant for the ALY CWA.

3. **Evaluate whether the trainee determined the following climatological information for May 31st:**
   - This day of the year is approaching the peak season for tornadoes and hail.
   - This day is in the early part of the severe wind season.
4. **Ask the trainee to click on the “animations” button on the top of the page to begin to analyze the magnitude of the severe weather probabilities relative to surrounding areas. State that the goal of the next exercise is for the trainee to determine:**
   - whether the probabilities are a local maximum/minimum in the region.
   - how the probability relates to the peak probabilities nationally.
5. **Under the “All Severe Weather” table have the trainee analyze the three animations (tornado, severe hail, and severe wind) for the 1980-1999 time period. After the loop has loaded, instruct the trainee to stop the loop and page through to find closest image to May 31.**
6. **Under the “High End Severe Weather” table have the trainee analyze the four animations (F2+ 1921-1995, F4+ 1921-1995, 2"+ hail, and 65+ kt wind). After the loop has loaded, instruct the trainee to stop the image and page through the loop to find the closest image to May 31.**
7. **Ask the trainee to summarize the analysis of how the local probabilities relate regionally and nationally.**
8. **Evaluate whether the trainee determined the following:**
   - Weak probabilities for tornado, severe hail and wind extend into the southern part of the CWA for this time of the year.
   - Probabilities are relatively weak for tornado and severe hail, and they are stronger for severe wind.
   - There is no signal of enhanced probabilities for significant tornado (F2 or greater), large hail (2” or larger), and significant wind (65 kts or greater) in the ALY CWA around May 31.
9. **Discuss the role of climatology in the warning process with the trainee and the limitations of climatological databases. Recognition of severe**

weather threats relative to climatology can be used to attain better situation awareness if used appropriately. Be sure to point out that:

- Just because climatology suggests a higher or lower probability for a particular severe weather type doesn't mean that it will or won't occur on any given day.
- The databases contain many errors and limitations given the relatively short time period and reporting issues.

II. Environmental Analysis

A. Synoptic Assessment (from PCU #3 of the Severe Convection PDS)

The suggested completion time for the Synoptic Assessment section is 1 hour and 40 minutes.

The objectives of the synoptic assessment are:

- To analyze the environment to determine if current (or future) large scale processes and patterns are favorable for severe convection. By incorporating a four-dimensional analysis of the data at this scale, one can determine the potential for subsequent severe weather development and achieve an understanding of the physical processes.
- Compare your current synoptic analysis to a synoptic climatology. Use your knowledge of environmental climatological patterns in your region to recognize potential heightened threats associated with the patterns and associated parameters. (See http://cstar.cestm.albany.edu:7773/COMETtraingnet/tornado%20derececho.htm for an example of synoptic climatology applied to the ALY CWA).
- Evaluate model forecasts of synoptic-scale features for the period up to 0000 UTC June 1st 1998.
- Relate the evaluation to the expected severe weather threat.

(Period analyzed is 1200-1800 UTC)

Trainer Tasks - Set Up

1. Close down any existing D2D sessions, and start the simulator for the time period 2007 UTC on May 31st, 1998 to 2205 UTC on May 31st, 1998. Doing so will prevent any of the data after the analysis period from being visible.
2. **Stop the simulator immediately to allow the trainee to investigate the environment up to the start time**
3. **Set the start time on the D2D display to 1845 UTC May 31st, 1998. To do this:**
    - Click with the left mouse on the “Time:” display on the bottom right-hand part of the D2D window.
    - Enter the year, date, and time after clicking on “Set Time”.
    - Click “OK”.
4. **Copy any procedures from the real-time AWIPS over to the WES machine.**

Specific Job Tasks and Skills and Knowledge (JTSK)

JTSKs are specific job task skills in a Professional Competency Unit (PCU). The PCUs and JTSKs are a part of the Convective PDS training format located at http://wdtb.noaa.gov/resources/PDS/newconvectpds.htm.

JTSK 1. Analyze surface and upper air data.

Analyze the upper air plots.

1. Ask the trainee to load 925, 850, 700, 500, 300 and 250 mb raob plots for 1200 UTC to analyze Look for the presence of salient features such as shortwave troughs, thermal troughs, low-level thermal/moisture axes, mid-level dry intrusions, upper- and lower-level jet streaks, and static stability.
2. **Discuss the summary with the trainee.**
    - **250 mb analysis summary**: Observations indicate a trough axis over the western Great Lakes. An anticyclonically curved 100 kt jet maximum is located over Southern Quebec. No significant along-stream acceleration or deceleration can be seen. Another cyclonically curved 120 kt jet maximum is located over Iowa. A significant left exit zone exists across Southern Michigan where a 45 kt along-stream deceleration exists between KDVN and KDTX. Northwesterly winds at KILX, eastward to KWAL have a significant northerly ageostrophic wind component possibly causing an east-west axis of diffluent flow from Northern Indiana to Pennsylvania.

- **500 mb analysis summary:** A north-south short-wave trough axis is located from Western Ontario through Lake Superior. A cold core (<-14^{o}C) is confined to the Northern Lakes and areas north. Upstream 500 mb temperatures are around -12^{o}C. The -9^{o}C temperature at Detroit appears anomalous and may be related to convective interference. A large area of > 50kt WSW winds lies north of a Central Illinois to Lake Erie line. Winds at KILN and KPBZ are much lower.
- **700 mb analysis summary:** The short-wave trough axis is displaced slightly east of the 500 mb axis. Strong winds of > 40 kts lies north of KILX eastward into Northern New York state. A tongue of warm air (> 10^{o}C) extends from KDVN eastward to KPBZ and then southwestward to Eastern Tennessee. This tongue appears to be an extension of an Elevated Mixed Layer (EML) that originated over the high terrain of the Central Rockies. This tongue also appears to be relatively dry and headed for at least the southern part of the Albany CWA. This warm tongue leads to 700-500 mb temperature differences exceeding 20^{o}C.
- **850 mb analysis summary:** A strong temperature gradient associated with a warm front lies on a NW to SE axis from the St. Lawrence Seaway to Eastern Massachusetts. Southwesterly winds of 20 kts and little wind shift characterize this baroclinic zone. A strong southwesterly low-level jet of at least 40 kts extends from the Ohio Valley into Western Pennsylvania and New York. Temperatures range from 17 to 19^{o}C in this low-level jet while dewpoints average around 10^{o}C.
- **925 mb analysis summary:** A wind shift line marks the edge of the warm front crossing the 925 mb level remains west of Albany but has passed east of Long island and Chatham. Dewpoints remain low until further west at KPBZ and KDTX. A 40 kt low-level jet is seen at this level in Ohio and northeast into Western Pennsylvania. Strong positive moisture advection is implied in Central and Eastern New York.

Evaluation points

3. **Did the trainee note the warm 700 mb temperatures in Western Pennsylvania but not further north? Were these warm temperatures identified as being part of an EML extension from the Rockies?**
4. **Did the trainee note the warm front location at 850 and 925 mb and the strong 40 kt low-level jet over the Eastern Ohio Valley and Pennsylvania?**

5. **Did the trainee notice the potential for rapid moisture advection and destabilization for later in the day?**

Analyze the regional scale surface map

1. Ask the trainee to load the regional or CONUS-scale surface observations for and view 1200 UTC or 1300 UTC, whichever yields more observations. Apply whatever density is required to complete the analysis. Overlay the GOES IR image.
2. **Discuss the summary with the trainee.**
   - The surface warm front remains west of a line from Watertown to Monticello to New York City. This warm front joins a surface low over Northern Lake Huron. Widespread low to mid 60s dewpoints lie to the west of this line with the strongest southwesterly winds in Ohio up to Western New York. This is the same general area as the 850 mb low-level jet. The surface cold front extends from the low southwest through Central Lower Michigan. Winds shift from southwest to west-northwest across the front and there is a weak thermal gradient. Thunderstorms, indicated by cold cloud tops are located in Southern Ontario, west of Buffalo and in the Adirondacks. The storms west of Buffalo are the remnants of a derecho that swept through Michigan earlier in the morning. At this time, the storms do not significantly alter the surface winds although there are surface temperature deficits in the wake of these storms. The storms in the Adirondacks appear to be associated with the warm front.

1. Did the trainee properly analyze the relevant surface features?

Analyze regional RAOBs.

Analyze the soundings in order to assess buoyancy, vertical wind shear, and other convective parameters.

1. Ask the trainee to load the KPIT and KALY 1200 UTC soundings to analyze important wind, temperature, and moisture variability over the region. Note that the KBUF sounding is unavailable.
2. **1200 UTC KALY Skew-T analysis summary: A warm frontal surface is noted just above the 900 mb level. Moisture increases to nearly 12 g/kg**

at 850 mb. The elevated moisture yields an elevated CAPE of over 1000 j/kg.

Note to WES trainers: The source of the “forecast max temp” in AWIPS is **not** the same as “anticipated” max temps. It is computed based on a combination of three variables: 1) the climatological monthly max/min temp, 2) relative humidity and cloud cover in the sounding, and 3) the total amount of energy available for heating and the sounding temperature profile. There are known limitations for using this technique. See http://meted.ucar.edu/awips/validate/index.htm.

- A realistic CAPE based on anticipated max temps /dew-points along and south of the warm front (78/66) yields approximately 2000 J/kg and a Lifted Index of -6.6°C.
- There is little to no CIN below the LFC when this parcel is lifted.
- In addition to the large CAPE, steep lapse rates, and very high EL (41 kft), wet bulb zero height (10.3 kft) 0-6 km shear of 40 kts suggest a large hail potential.
- However 700 mb warm advection might limit the potential CAPE and add a capping layer for those points downstream of the Pittsburgh sounding.
- Using the forecast maximum temperature/ dewpoint of 78/66 yields a theta-E of 342^{o}K. The minimum theta-E in the 500-700 mb layer is about 316^{o}K at 660 mb theta-E, the surface to 660 mb theta-E difference would be approximately 26°K. This dry layer at 660 mb is only 80 mb deep with near saturation from 700 mb and below. The dry layer in the 800 - 850 mb layer is expected to be quickly moistened with the lifting of the warm front. Therefore purely evaporatively driven microburst processes would be limited. More dry midlevel air is available upstream sampled by the Pittsburgh sounding.
- Midlevel winds (850-700 mb) are 35-45 kts in addition to the 0-6 km shear of 35-40 kts suggest the potential for bows. The vertical shear profile at KALY suggest supercells are possible. The 0-3 km SRH (based on 30R75) is 287 m^2/s^2.
- Rapid changes in the boundary layer are expected, including a veering of surface winds with the expected passage of the surface warm front.

3. **1200 UTC KPIT Skew-T analysis summary: This sounding is more capped (Instability indices based on a forecast MAX temp/dewpoint of 80/66; LI = -7°C, CAPE = 2410 j/kg, CIN = -5 j/kg).**
   - The LFC is forecast to be at 650 mb, much higher than that of KALB. Steep lapse rates from 500 - 700 mb along with a dry layer suggest this airmass was either EML derived from high terrain of the Rockies or a layer with a history of subsidence. This layer appears to be advecting east-northeast, possibly affecting the southern zones in the ALY CWA.
   - The steep lapse rates and dry midlevel air could add to the hail size potential. However, the dry air is partially compensated by the warmer layer to result in a similar wetbulb zero height (10.6 kft).
   - This sounding has an estimated northwest 0-6 km bulk shear vector around 35 kts, slightly less than KALB, still sufficient for supercells. Measured SRH is still significant with the most contribution from the lowest 200 m.
   - Theta-E differences from surface to the driest layer in the 700-500 mb layer (660 mb) is similar to KALB (25^{o}K), however the dry layer extends down below 700 mb resulting in slightly higher downburst potential from purely entrainment-driven evaporative processes. However, damaging straight line winds seem likely as any drowndraft would vertically transfer the strong 850 mb winds found in this sounding.
   - The 700-500 mb temperature difference is 21^{o}C, while at KALB, it is only 13^{o}C. The 850-500 mb temperature difference is 29^{o}C, 3^{o}C more than at KALB. However, KALB has a steeper 850-700 mb lapse rate than KPIT.

Evaluation points

4. **Did the trainee correctly modify the Albany sounding due to expected afternoon surface temperature and dewpoints?**
5. **Did the trainee recognize the modified sounding is favorable for supercells and bow echoes?**
6. **Did the trainee notice the layer with steep lapse rates at Pittsburgh and relate them to the potential for severe weather with logical reasoning?**

Use of compositing techniques.

As a part of the diagnostic forecast process, use compositing techniques to superimpose salient synoptic scale features and assess any particular juxtaposition of the features for the purpose of recognizing the pattern and associated severe weather type.

1. **Summary of 1200 UTC compositing techniques:** The location of synoptic scale features, including a mobile shortwave trough passing to the north and strong west-southwesterly midlevel flow suggests a pattern associated with past tornado outbreaks in the ALY CWA. (Also, see http://cstar.cestm.albany.edu:7773/COMETtraingnet/tornado%20derececho.htm and http://cstar.cestm.albany.edu:7773/COMETtraingnet/flow.htm for a good description of severe weather patterns for the ALY CWA.) There will be a question on this pattern in the evaluation section.

Evaluation point

2. **Did the trainee compare the broad synoptic features at 12 UTC to the composite bound in the web pages above differentiating tornadic from mostly derecho severe wind events?**

JTSK 2. Using a knowledge of severe convective patterns and known model biases, perform an integrated 4-D analysis of future (or expected) synoptic parameters to evaluate the large-scale threat of severe convection in your CWA in the next 12 hours.

a. Evaluate changes in convective potential using numerical model data.

b. Determine expected (or forecast) sounding/hodograph parameters based on modifying the sounding using gridded model data.

1. Ask the trainee to load the 4-panel ETA family on a regional scale for the 1200 UTC output.
2. **Summary of 4-panel ETA family on regional scale for the zero to 12 hour forecast period:**
   - The 500 mb heights and vorticity field in the upper-left panel shows that a strong vorticity maximum over Lake Huron will quickly move into Central Quebec by 00Z. However, the trailing end of the vorticity max will remain just to the west of the CWA throughout the day.
   - A strong surface low (989 mb) is forecast to move from Lake Huron to South Central Quebec and slightly deepen to 984 mb.

- The trailing cold front is forecast to approach the CWA by 00 UTC. Meanwhile the warm front is forecast to lift north of the CWA by 18 UTC.
- Ascending air at 700 mb is forecast to overspread the CWA between 18 and 00 UTC with a maximum value of -5 μb/s. This ascent appears to be related to the tail end of the strong vorticity maximum lifting into Quebec.

3. **Evaluation point**
   - Did the trainee note the approach of the cold front but with the 700 mb ascent preceding the surface front?
   - Is the trainee's anticipation of convective initiation based on physical processes?
4. **Ask the trainee to load these parameters onto the upper-right panel of the 4 panel family.**
   - 2-D frontogenesis function for 700 and 925 mb
5. **Summary of frontogenesis functions**
   - The 925 mb frontogenesis peaks in a band collocated with the surface cold front. It does not currently explain the existence of the pre-frontal convection.
   - There is negligible frontogenesis found at the 700 mb level.
   - Therefore the ETA model cannot support elevated frontogenesis as a mechanism forcing the pre-frontal convection.
   - Elevated frontogenesis may exist with events similar to this and may also lead to forcing boundary-layer pre-frontal convection. However, since it cannot be determined with the analysis in this case, the pre-frontal convection probably originated elsewhere.
6. **Ask the trainee to either clear or use a new display and then to load these isentropic parameters for the 310 K surface:**
   - The ETA model pressure,
   - The ETA wind,
   - The ETA condensation pressure deficit,
   - The ETA net adiabatic omega.
7. **Summary of the 310 K isentropic level**
   - The 12 UTC analysis shows strong apparent isentropic upglide across PA, and New York ahead of the surface cold front.

- By 18 UTC, the net adiabatic omega finds the a center of ascent focused in Western PA with weak or neutral ascent in New York. However, the model ascent is located just upwind of enhanced humidities as shown by the reduced condensation pressure deficits in the ALY CWA. The horizontal advection of pressure surfaces has negated most of the inferred isentropic ascent in this region after 18 UTC.
- This area of isentropic ascent does NOT agree with the 700 mb omega, even though it crosses through 700 mb layer in the same area. By 00 UTC, isentropic ascent has disappeared, however the 700 mb omega reaches its maximum value.
- It appears that there is sufficient, though weak, isentropic ascent in the 310 K layer to help destabilize the atmosphere in a broad region ahead of the cold front. Sufficient destabilization does occur in broad ascent but it is probably not responsible for triggering the pre-frontal convection.
- Further analysis of the surface and satellite data later in this section may provide a reason for this pre-frontal convection initiation.

8. **Ask the trainee to either clear or use a new display. Ask the trainee to load these ETA parameters:**
   - 0 - 6 km bulk shear from the Convective menu within the Volume Browser
   - 850 mb winds
   - 0 - 3 km bulk shear from the Convective menu within the Volume Browser
   - 0 - 120 mb AGL bulk shear by subtracting the 850mb from the surface winds
   - “Corfidi” vectors from the Convective menu within the Volume Browser and their magnitudes
   - Right-moving supercell motion from the Convective menu within the Volume Browser
9. **Summary of shear and propagation parameters**
   - Increasing westerly 0 - 6 km bulk shear is forecasted by the Eta across the ALY CWA, reaching 50 kts in the eastern CWA by 00 UTC. None of the weaker northwesterly shear evident in the 12 UTC PIT sounding is expected near the CWA.
   - In addition, 0 - 3 km shear values are expected to slowly increase to 40 kts or better with a slight tendency for higher values north of Albany.
   - Assuming the tornadic potential of storms is most modulated by the shear in the 0 - 1 km layer, the approximate surface - 120 mb AGL bulk shear

increases to 35 kts by 18 UTC over most of the CWA. This increase is above the normal “threshold” values of 20-25 kts currently used by the Storm Prediction Center in its methodology to determine a significant tornado threat.

- Forecast right-moving supercell motions, based on the Bunkers method, also increase throughout the 0 -12 hour period. Westerly storm motions are expected to exceed 35 kts.
- MBE (‘Corfidi’) motions assume a well developed back building multicell complex. If such an event occurs, a back building motion would be to the southeast around 20 kts, much slower than the wind speeds in all the vertical levels. However, should a multicell complex become a forward propagator, then the propagation component to the MBE vectors is added to the mean 0 - 6 km winds may result in maximum east-southeastward motions greater than 65 kts.

10. Evaluation points

- Did the trainee note the increase in the 0 - 6 km shear by 00 UTC as an increasing indication of supercell potential?
- Did the trainee recognize the increasing right-moving supercell speeds with time and what effect that might have on warning operations?

11. Ask the trainee now to load these parameters from the Volume Browser.

- 0 - 3 km Storm Relative Helicity (SRH)
- 550-600 mb Storm Relative Flow
- Surface-Based CAPE (SBCAPE)

12. Summary of SRH and Storm-Relative flow

- The SRH (0-3 km) off the ETA was depicting max contoured values from around 300-500 m^2/s^2 to develop by 1800 UTC across the ALY CWA. The highest values in this range appear to align themselves with the Hudson River Valley. The super high values forecast in the Adirondack mountains appear not to be associated with surface-based instability. Therefore, the effective helicity may be lower. Present climatology parameter studies indicate the 0 - 1 km layer is a better significant tornadic vs. nontornadic discriminator. This layer is likely very sensitive to topographic channeling by the Hudson River Valley.
- Midlevel (500 mb) Storm-Relative (SR) flow magnitude is forecast to remain in the 20-25 kts range through 0000 UTC. There is still uncertainty

in climatological parameter studies about whether midlevel SR flow can discriminate tornadic and nontornadic storm environments. However, it is theorized that the SR flow mentioned here may be enough to separate precipitation from the mesocyclone and allow supercells to become tornadic.

13. Evaluation point

- Did the trainee note the enhanced SRH along the Hudson Valley?
- Are the trainee's expectations for tornado potential based on low-level shear and SRH reasonable?

14. Ask the trainee to load this parameter from the Volume Browser:

- Surface theta-E

15. Summary of Buoyancy parameters

- The Eta forecasts a theta-E ridge axis to develop ahead of a NE to SW swath of model-generated precipitation through Eastern New York and Western New England through the 6-12 hour time frame. A similar nose of high SBCAPE also appears with maximum values to the southwest of the ALY CWA (12-1600 j/kg). Convective overturning by the Betts-Miller convective parameterization scheme reduces the SBCAPE west of the CWA after 18UTC.

16. Evaluation point

- Did the trainee recognize that the production of convective precipitation reduces the CAPE through overturning?
- Is the trainee's expectations for convective instability reasonable?

17. Ask the trainee to add these parameters from the Volume Browser:

- Bulk Richardson Number shear (BRNshr)
- Energy Helicity Index (EHI)
- Vorticity Generation Parameter (VGP)

18. Summary of BRNshr and EHI parameters

- BRNshr forecasts show values well in excess of the threshold 40 m2/s2 considered favorable for supercells over all of New York. The highest values initially start over the Adirondacks. However, these values are unrealistically high owing to the convectively stable boundary layer which occupies the lower part of the BRNshr layer. Elsewhere in New York, the combination of high CAPE and favorable BRNshr suggests supercells are possible, especially in the Hudson Valley where a relative maximum in BRNshr is forecast between 18 and 00 UTC.

- Energy Helicity Index (EHI) values also suggest good supercell potential provided convection initiates throughout New York, southwest of the Lake Champlain valley. Maximum values become collocated with the Hudson River Valley between 18 and 00 UTC. The EHI is an attempt to gauge the potential conversion of 0-3 km SRH into rotating updraft. Either high updraft velocities (from high CAPE) or high SRH can compensate for the lack of the other to arrive at high EHI values.
- The Vorticity Generation Parameter, VGP, values follow a similar trend to EHI. The VGP is similar to the EHI except it uses the concept of tilting horizontal vorticity into vertical vorticity. High CAPE and/or high vertical shear can compensate for the lack of the other parameter to produce relatively high VGP.

19. Evaluation point

- Does the trainee's expectations change by viewing these parameters instead of viewing their individual components?
- If any expectations changed, is the trainee's reasoning valid?

Note: For a discussion of some important environmental parameters for forecasting severe weather type, see pages 16-29 (Lesson 3) of the WDTB DLOC training student guide on Convective Storm Structure and Evolution. (This document is available on the WDTB website at http://wdtb.noaa.gov.)

20. Ask the trainee to bring up a clear display pane. Then begin to load the ETA model and the observed raob soundings for:

- Albany 12 UTC,
- and Pittsburgh, PA 12 UTC.

21. Summary of ETA/Raob comparisons.

- The 12 UTC ETA/Raob comparison at Pittsburgh shows a some errors in the thermal and moisture profiles, the most notable being the lack of resolution depicting the sharpness of the capping inversion observed in the Raob at 725 mb. However, that lack of resolution is an artifact of the 50 mb vertical resolution of the model data sent on the 211 grid. It is not known whether the Eta model native resolution adequately captured the strength of the inversion. However, the observed Raob was 2^{o}C warmer than the ETA analysis.

- The ETA has reasonably captured the kinematic profile except for the shear from the surface to 0.2 km. This results in a large discrepancy in the estimated SRH with the observed sounding recording the higher with 317 m^2/s^2.
- A similar comparison made for Albany shows the Eta underestimated the amount of observed moisture in the 700 to 850 mb layer and overestimated the same for the 850 to 1000 mb layer.
- Kinematically, the observed sounding has stronger winds in the lowest 1 km. Otherwise no significant differences are noted.

22. Evaluation point

- Does the trainee recognize the effects of limited vertical resolution of model soundings from the 211 grid?

23. Ask the trainee to bring up a clear window or erase everything on the present display. Then begin to load the ETA model soundings for:

- a point in Warren County for 12 - 00UTC,
- a point in Ulster County for 12 - 00UTC,
- and a point between Otsego and Delaware County for 12 - 00UTC.

24. Summary of ETA forecast soundings:

- All of the soundings appear to lose the steep midtropospheric lapse rates between 12 and 18 UTC, possibly as a result of being modified by the Betts-Miller convective scheme. Therefore, the forecast CAPE might be slightly underestimated over a large portion of the CWA, especially for the south half. In addition, the increased midlevel moisture raises the wetbulb zero heights by 1000 ft.
- Nevertheless, all the soundings show low LCLs, little CIN and unstable boundary layers. All soundings show large counterclockwise looping hodographs, becoming larger with increasing latitude, by 18 UTC.
- SRH values range from 300 to 600 m^2/s^2 but diminish somewhat by 00 UTC as low-level winds veer in response to the surface low moving further east into Quebec.

25. Evaluation point

- Did the trainee note the low LCLs as being favorable for tornadic storms?
- Did the trainee anticipate that organized wind potential from bows is also high in environments with high midlevel winds and strong shear?

Know how to utilize remote sensing data to augment model initial conditions.

1. Ask the trainee to bring up a clear display and load 20 frames of the regional GOES-8 VIS loop. Overlay the 5 minute lightning data and Metar data.
2. **Overlay the ETA 700 mb temperatures, and the surface potential temperatures.**
3. **Summary of analysis of satellite and other remote sensing data at 1300-1845 UTC.**
   - A line of thunderstorms quickly form over Lake Ontario and move east into the Adirondacks before dissipating. A second line forms over Lake Erie and continue as broken cells into Central New York at the end of this loop. Both of these lines do not create cold pools intense enough to significantly alter the surface wind or thermal patterns. Winds veer slightly to a more southwesterly direction as the convective lines pass and remain that way in Western New York through the afternoon. This broken line of thunderstorms extend southwest as a belt of mid-level liquid clouds into Northeast Ohio by 17 UTC.
   - By 17 UTC, another line of thunderstorms develop on another ENE to WSW wind shift line in South Central Michigan.
   - The initiation mechanisms of these two lines appear to be different. The line in Southern Michigan appears to be initiated by the surface cold front, while the more eastern line may have its initiation sources from more elevated sources.
   - However, inspection of the ETA model and the long-period satellite loop from 13 UTC suggest that the diminishing derecho which swept through Michigan the night before may be continuing an outflow embedded in the strong synoptic near surface flow, which then initiates new convection through diurnal heating in an uncapped atmosphere in Western New York. Note that no convection initiates closer to where the Pittsburgh sounding has been launched.
   - In any case, the lack of a dominating cold pool may allow more isolated modes of convective initiation to occur within this line as it moves east. The trainee may wish to display a model cross-section from Lake Superior to the Chesapeake Bay and overlay potential temperature, wind, RH, 2-D frontogenesis and omega from the ETA model run to analyze the structure of the front and its relation to both lines of convection at 17-18 UTC.

4. **Ask the trainee to overlay the Storm-Relative Winds for the 300 mb level from the ETA model**

5. **Evaluation point**
   - Did the trainee correctly note that the morning broken line of thunderstorms is not actually associated with the surface cold front?
   - Is the trainee's expectations for the potential of various severe weather types change upon viewing the satellite data based on correct physical understanding?

6. **Summary of 300 mb Storm-Relative flow:**
   - New convection forming at the end of the period north of Binghamton develops an anvil which expands outward in all directions but with a preference to the north.
   - This is consistent with the storm-relative 300mb winds which show 25-30 kt southwesterly flow. Relatively light anvil-layer storm relative flow has been related to instances where isolated supercell storms quickly transition to the high-precipitation variety (HP) storms. While the tornado threat may not be affected, HP storms do tend to produce high winds, and heavy precipitation.

JTSK 3. Forecast general type of severe weather based on evaluation of patterns and parameter values.

1. Have the trainee draft a Hazardous Weather Outlook (HWO) describing the threats of severe weather expected in the Albany CWA for the day ending on 0000 UTC June 1st, 1998. The trainee should address a relative threat (slight, moderate, high) for each of these elements:
   - severe wind,
   - large hail,
   - flash flooding,
   - and tornadoes.

2. **Summary of synoptic analysis relating to the 1845 UTC HWO:**
   - Based on analysis of the current data including the synoptic environmental pattern, plus the ETA model forecast signals, there appears to be a high chance of a significant severe threat across the CWA during the afternoon of the 31st. Significant CAPE values with little CIN and strong low- to mid-level winds suggest potential for damaging winds threat. Also, supercells with large hail are possible given the strength of the 0-6 km

shear. Low-level SRH, 0 - 1 km shear, low LCLs and high EHI from the ETA model suggest a significant chance for tornadic development. Flash flooding is not considered a significant threat due to fast forward propagation of storms.

- More analysis is required from real-time data and higher resolution model output to help specify the threat and the potential impact areas in the CWA. The next analysis time will be starting at 1945 UTC.

3. **Evaluation point**
   - Did the trainee concisely convey the level of threat expected from severe winds, hail, tornado and flash flood?

B. Mesoscale Assessment

Suggested completion time: ***80 minutes***

The objectives of the mesoscale assessment are:

- Identify important variations of the environment across the CWA.
- Create a shift-change briefing that relates the environment analysis to the threat of severe weather (tornado, severe hail and wind, and flash flooding).

The analysis utilizes the following components (specific job tasks, skills, and knowledge) from the Convective Professional Development Series, PCU #4:

1. Determine buoyancy and shear-related characteristics of the mesoscale environment for the purpose of anticipating potential convective storm types through the use of upper-air observations and model output (i.e. hodographs and Skew-T diagrams).

2. Apply conceptual models of cloud microphysics, convective mesoscale processes, and storm life cycles for the purpose of identifying convective storm types and associated hazardous weather threats in the 0-6 hr. time frame.

3. Using all available in-situ and remote-sensing observational data, numerical model data, and SPC guidance, maintain a high level of situation awareness with respect to the evolution of mesoscale boundaries,

buoyance fields, vertical wind shear profiles, storm movements/interactions, and existing watches, warnings, and advisories.

4. Evaluate convective initiation aspects in your CWA (i.e. potential timing and location).

To assess the mesoscale environment, the trainee will be asked to evaluate surface observations, satellite, MSAS, LAPS, VWPs, and radar data at 2007 UTC using D2D. The analysis techniques provided should be modified to include local preferences (i.e. different parameter fields, hand analysis) if desired.

2007 UTC Mesoscale Analysis

1. Change the time to 2007 UTC on May 31st, 1998 by left-clicking on the time in the D2D display on the lower right portion of the window and entering the date and time.
2. **Ask the trainee to analyze and summarize the past few hours of evolution of the metar observations as they relate to convective initiation. Have the trainee load a 32-frame state-scale visible satellite loop, then overlay surface observations with the CWA boundary. In another pane, have the trainee load a 32-frame state-scale KBGM 0.5 degree reflectivity image overlaid with hi-res topography.**
3. **Discuss the summary with the trainee. Some considerations for discussion include:**
   - There is a lack of surface observations in large parts of the CWA.
   - Overall, convective initiation features are weakly defined over much of the CWA.
   - Some of the strongest convergence indicated by the METAR data appear to be contaminated by convection (see the 18 UTC KPEO and 19 UTC KUCA observations).
   - There is weak surface convergence ahead of the southwesterly winds in the western part of the CWA that can be contributing to convective initiation over Otsego and Delaware Counties.
   - Most of the storms in central and western New York have formed in a broad area of southwest winds ahead of the main front in Canada.
   - Radar depicts storms forming on the elevated terrain are now moving toward the lower terrain of the Hudson River Valley.

4. **Ask the trainee to begin analyzing the objective analysis fields of the mesoscale environment by analyzing the MSAS data. MSAS fields, though limited in number, are optimal for obtaining a larger scale perspective of the environment in areas of varying terrain. Have the trainee load and then summarize the MSAS NWS MSLP, 3 hr Pres Change, and LI fields.**

5. **Discuss the summary with the trainee. Some considerations for discussion include:**
   - The surface low continues to move off to the northeast along the isallobaric gradient, and the winds have veered in response over western New York.
   - Pressure falls are maximized to the northeast and east of the CWA indicating surface winds may veer with time.
   - Metar observations show the winds are still relatively backed in the Hudson River Valley which will likely increase low-level shear and helicity.
   - Breaks have formed in the cirrus allowing surface temperatures to reach the low 80s with mid-upper 60 dewpoints in the Hudson River Valley (central part of the CWA) south of the warm front.
   - The very unstable surface air over the northeastern US continues to advect north behind the warm front. LI's of -7 exist in the southwestern half of the CWA, and instability is less over the northern and eastern part of the CWA.

6. **Ask the trainee to continue analyzing objective analysis fields of the mesoscale environment by analyzing the LAPS data. Focus the analysis over how the mesoscale environment has changed over the last few hours relative to the 1200 UTC ETA forecast analyzed earlier. Have the trainee load surface observations on state scale, and use the volume browser to overlay LAPS CAPE, CIN, 0-6km bulk shear vectors, 0-3 km shear, and the right moving supercell storm motion (note helicity is absent from the analysis because LAPS helicity is not storm-relative which is the standard).**

7. **Discuss the summary with the trainee. Some considerations for discussion include:**
   - CAPEs are estimated to be around 2000 j/kg in the Hudson River Valley and about 1200 j/kg on the higher terrain in the western part of the CWA. Note that the CAPE fields are noisy because of the scarcity of observa-

tions, the effect of elevated terrain on the objective analysis, and some unusually high dewpoints (see 19z 72 F dewpoint at KPOV and KMSS).

- CIN is estimated to be low (-20 j/kg to zero) over most of the area south of the warm front.
- 0-6 km shear (50 kts) and 0-3 km shear (40kts) are estimated to still be strong, as previously forecasted
- Right-moving supercell storm motions are estimated to be ~ 260° at 25 kts (southern part of the CWA) and 45 kts (northern part of the CWA).

8. **Ask the trainee to identify significant differences in the LAPS perspective of the mesoscale environment over the CWA.**
9. **Discuss the summary with the trainee. Some considerations for discussion include:**
   - Stability maximum over the eastern part of the CWA where temperatures and dewpoints are both relatively low
   - Instability maximum over the central part of the CWA
   - Less instability over the western third of the CWA on the elevated terrain
10. **Ask the trainee to analyze and summarize the LAPS point soundings over the areas of mesoscale variability in the LAPS analysis. First have the trainee load a 32-frame KBGM 0.5 degree reflectivity loop and overlay surface observations, LAPS CAPE, the CWA boundary, and the points under the tools menu. Have the trainee load LAPS soundings in another pane using WFO scale and the volume browser for central Bennington County, central Saratoga County, and central Schoharie County. Pay special attention to whether the surface temperature and dewpoints appear reasonable with the observations.**
11. **Discuss the summary with the trainee. Some considerations for discussion include:**

a. Bennington County LAPS sounding:

- Little, if any, CAPE exist for a temperature of 67 F and dewpoint of 56^{o}F (note small increases in temperature and dewpoint based on surrounding surface observations can easily change this).
- The lack of observations in the eastern part of the CWA along with steep terrain gradients provides a large degree of uncertainty in the actual environment at this location.

- Strong 0-6km shear (estimated 45 kts) supports supercells and large hail if CAPE is higher.
- 0-3km SRH ~ 350 m^2/s^2 (using hodograph with storm motion of 260° at 35 kts) is high, supporting significant tornado threat if CAPE is higher.
- Strongest shear is confined to lower levels, supportive of tornadoes.
- 40-50 kt wind in the 850-700mb layer with moderate flow aloft (50-60 kts) indicates damaging wind is likely.
- Wet-bulb zero height (11.6 Kft) is high, limiting hail sizes except with supercell storms.

b. Saratoga County LAPS sounding:

- Surface CAPE is low (~ 1600 J/Kg for 80/65). Modifying the dewpoint to 67^{o}F based on nearby representative observations yields a CAPE of 2200 J/Kg.
- CIN is low (~ -20 J/Kg).
- Strong 0-6km shear (estimated 50 kts) supports supercells and large hail.
- 0-3km SRH ~ 400 m^2/s^2 (using hodograph with storm motion of 260 at 35 kts) is high, supporting significant tornado threat.
- Wet-bulb zero height (11.6 Kft) is high, limiting hail sizes except with supercell storms.
- T/Td spreads are low (< 15^{o}F), decreasing threat for strong cold-pool production with isolated storms and increasing risk for tornadoes.
- Low LFC (1300 m) and the associated presence of low-level CAPE (estimated ~ 150 J/Kg) increases threat for tornadoes (note: 0-3 km CAPE can be estimated by modifying a sounding to remove the 0-3 km cape, and subtracting the result from the actual CAPE).
- 45-55 kt wind in the 850-700mb layer with moderate flow aloft (50-60 kts) indicates possibility of damaging wind.
- relatively fast storm motion (35 kts) doesn't support widespread flooding except where storms train over the same area.

c. Schoharie County sounding:

- Surface CAPE is low (~ 700 J/Kg for 76/60); note small increases in temperature and dewpoint based on surrounding surface observations can easily change this
- The lack of observations in the western part of the CWA along with steep terrain gradients provide a large degree of uncertainty in the actual environment at this location.
- Some of the surrounding observations on higher terrain (KMSV and KBGM) show mid-upper 60^{o}F dewpoints have made it up to the higher terrain around 1300 ft ASL, suggesting the actual CAPE is likely higher than LAPS suggests.
- Terrain varies from 700 ft ASL to 2300 ft ASL in Schoharie County, so considering a conservative dewpoint of 63^{o}F, the resulting CAPE is ~ 1500 J/Kg.
- CIN is low (~ -25 J/Kg).
- Strong 0-6km shear (estimated 45 kts) supports supercells and large hail.
- 0-3 km SRH ~ 400 m^2/s^2 (using hodograph with storm motion of 260 at 35 kts) is high, supporting significant tornado threat.
- T/Td spreads are low (< 16^{o}F), decreasing threat for strong cold-pool production with isolated storms and increasing risk for tornadoes.
- Although LFC is moderately high (1800 m), the presence of low-level CAPE (estimated ~ 140 J/Kg) increases threat for tornadoes (note: 0-3 km CAPE can be estimated by modifying a sounding to remove the 0-3 km cape, and subtracting the result from the actual CAPE).
- 35-50 kt wind in the 850-700mb layer with moderate flow aloft (50-60 kts) indicates a high potential of damaging wind.
- Wet-bulb zero height (11.6 Kft) is high, limiting hail sizes except with supercell storms.

12. Ask the trainee to analyze the VWPs from KBGM and KENX to determine if there are any significant differences in wind profiles compared to the eta forecast or LAPS analysis.

13. Discuss the summary with the trainee. Some considerations for discussion include:

- Both radars show strong low-level shear as forecasted
- The shear may be slightly stronger at KENX with more backed wind at 2Kft MSL and more veered wind at 4 Kft MSL relative to KBGM, but the storms nearby are likely contaminating the KENX VWP somewhat (also suggested by higher RMS errors).

14. Read the latest tornado watch from SPC in Appendix B.

15. Ask the trainee to create a shift-change briefing that summarizes the mesoscale analysis for the CWA, including:

- the level of threat for each severe weather type over areas of mesoscale variability in the CWA
- the expected evolution over the next 3 hours
- any potential limiting factors

16. Discuss the rationale behind the information conveyed. Some considerations for discussion include:

- Potential exists for a significant severe weather outbreak this afternoon throughout the CWA with significant tornadoes, damaging wind, and severe hail possible.
- Supercells expected with widespread strong deep shear and low-level shear over the whole CWA.
- Significant variations of instability exist over parts of the CWA.
- Significant uncertainty exists with diagnosing instability in the eastern and western parts of the CWA where there are no surface observations and the terrain is much higher and more variable.
- Highest threat for all severe weather will be where instability is strongest.
- Severe hail expected CWA-wide with supercells, though threat will be less with non-supercells due to high wet-bulb zero height.
- Damaging wind also possible with strong winds in low-mid levels and moderate winds aloft.
- Widespread flooding not anticipated with fast storm motions.

- Severe threat continues into the evening as more storms out west move into the CWA.

III. Summary

Suggested completion time for tasks 1 through 2: ***15 minutes***

1. Ask the trainee to summarize lessons learned from the exercise and how to apply these to local operations.

2. Discuss strengths and limitations of the forecast funnel approach for this event based on the analysis experience. Some elements to discuss include:

- the use of climatology to raise situation awareness of the range of threats for tornadoes, hail, and wind,
- the benefit of analyzing large scale motions first, followed by smaller scale analysis,
- the importance of using raw observations in combination with numerical model forecasts to best estimate the environment and anticipate severe weather evolution,
- the importance of recognizing variations in the environment over the CWA and their implications for input into the warning process,
- and that it is important remain aware of how the mesoscale environment evolves throughout the warning period.

Appendix A: Storm Reports

I. ALY CWA Reports

Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Herkimer County** Cedarville	1938	**Thunderstorm Wind**
2	**Herkimer County** Dolgeville	1938	**Thunderstorm Wind**
3	**Herkimer County** Frankfort	1938	**Thunderstorm Wind**
4	**Montgomery County** Fonda	1942	**Thunderstorm Wind**
5	**Fulton County** Gloversville	1945	**Thunderstorm Wind**
6	**Herkimer County** Mohawk	1945	**Thunderstorm Wind**
7	**Schoharie County** Schoharie	2010	**Thunderstorm Wind**
8	**Saratoga County** Milton Center	2015	**Hail (1.00)**
9	**Saratoga County** Mechanicville	2016	**Thunderstorm Wind (G 52)**
10	**Saratoga County** Saratoga Springs	2020	**Hail (1.75)**
11	**Saratoga County** .7 NNE Ushers to 1 NNE Mechanicville	2022 2027	**Tornado (F3)**
12	**Rensselaer County** 1.9 NNW Reynolds to 2.6 ENE Walloomsac	2027 2045	**Tornado (F2)**
13	**Schoharie County** North Blenheim	2030	**Thunderstorm Wind**

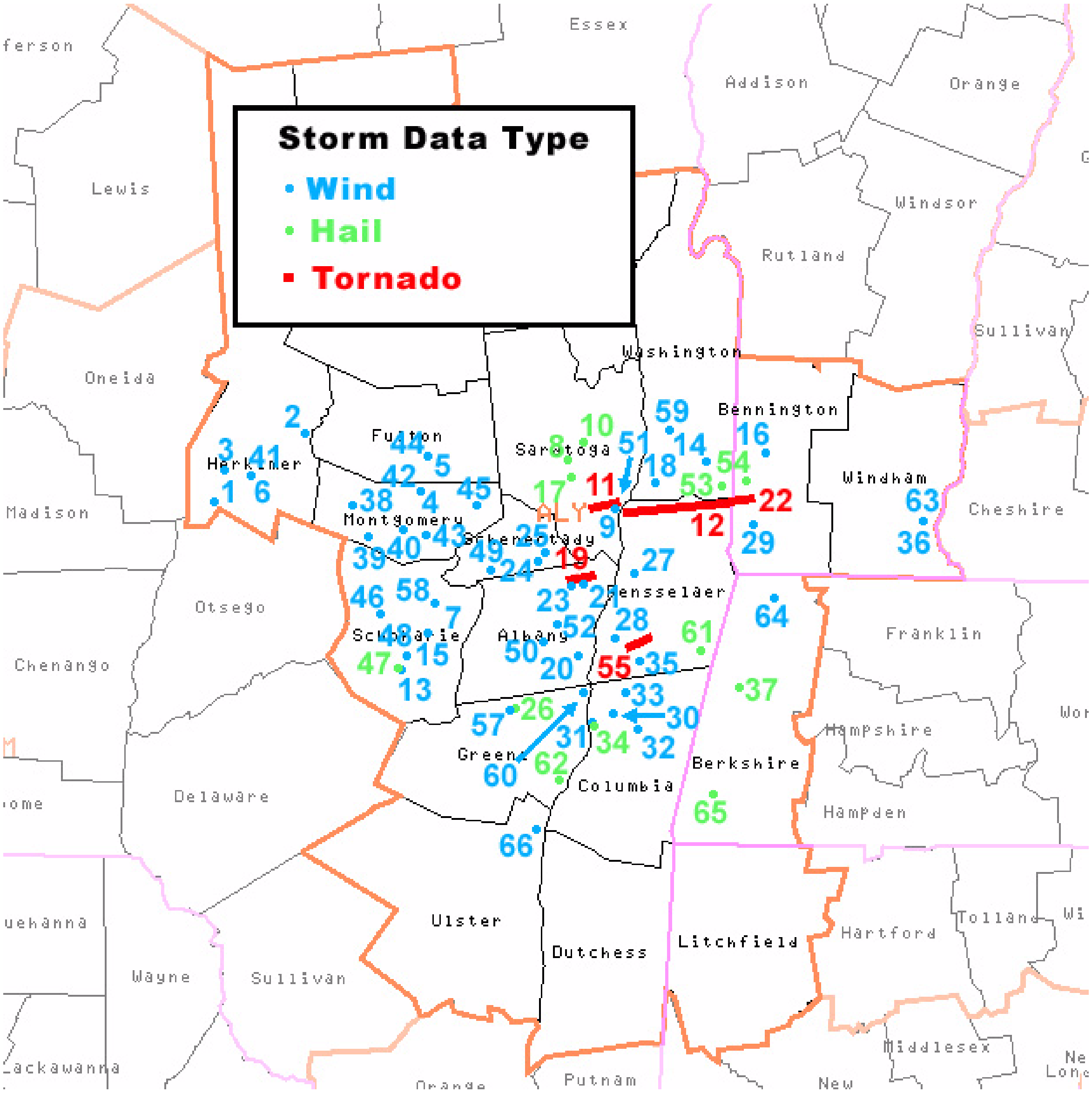
Rpt #	Location	Time (UTC)	Storm Characteristic
14	**Washington County** Cambridge	 2030	 **Thunderstorm Wind**
15	**Schoharie County** Middleburgh	 2032	 **Thunderstorm Wind**
16	**Bennington County** Arlington	 2032	 **Thunderstorm Wind**
17	**Saratoga County** Ballston Spa	 2035	 **Hail (0.75)**
18	**Washington County** Easton	 2035	 **Thunderstorm Wind**
19	**Albany County** 1.7 NNW Colonie .7 WNW Latham	 2037 2041	 **Tornado (F1)**
20	**Albany County** Bethlehem Center	 2038	 **Thunderstorm Wind**
21	**Albany County** Albany Airport	 2040	 **Thunderstorm Wind (G 71)**
22	**Bennington County** 1.7 WNW North Benning- ton to 2 ESE South Shaftsbury	 2045 2055	 **Tornado (F2)**
23	**Albany County** Colonie	 2050	 **Thunderstorm Wind**
24	**Schenectady County** Rotterdam	 2050	 **Thunderstorm Wind**
25	**Schenectady County** Schenectady	 2050	 **Thunderstorm Wind**
26	**Greene County** Greeneville	 2100	 **Hail (1.00)**
27	**Rensselaer County** Brunswick	 2100	 **Thunderstorm Wind**
28	**Rensselaer County** East Greenbush	 2105	 **Thunderstorm Wind**

Rpt #	Location	Time (UTC)	Storm Characteristic
29	**Bennington County** Bennington	2105	**Thunderstorm Wind**
30	**Columbia County** Kinderhook	2110	**Thunderstorm Wind**
31	**Columbia County** Stuyvesant	2110	**Thunderstorm Wind**
32	**Columbia County** Chatham	2120	**Thunderstorm Wind**
33	**Columbia County** Niverville	2126	**Thunderstorm Wind**
34	**Columbia County** Stuyvesant	2131	**Hail (1.00)**
35	**Rensselaer County** Nassau	2135	**Thunderstorm Wind**
36	**Windham County** Brattleboro	2142	**Thunderstorm Wind**
37	**Berkshire County** Pittsfield	2145	**Hail (1.75)**
38	**Montgomery County** Ft. Plain	2220	**Thunderstorm Wind**
39	**Montgomery County** Ames	2222	**Thunderstorm Wind**
40	**Montgomery County** Rural Grove	2224	**Thunderstorm Wind**
41	**Herkimer County** Mohawk	2225	**Thunderstorm Wind**
42	**Montgomery County** Fonda	2226	**Thunderstorm Wind**
43	**Montgomery County** Charleston	2228	**Thunderstorm Wind**
44	**Fulton County** Gloversville	2230	**Thunderstorm Wind**
45	**Montgomery County** Amsterdam	2230	**Thunderstorm Wind**

Rpt #	Location	Time (UTC)	Storm Characteristic
46	**Schoharie County** Richmondville	2235	**Thunderstorm Wind**
47	**Schoharie County** North Blenheim	2245	**Hail (0.75)**
48	**Schoharie County** Breakabeen	2247	**Thunderstorm Wind**
49	**Schenectady County** Duanesburg	2300	**Thunderstorm Wind**
50	**Albany County** Clarksville	2308	**Thunderstorm Wind**
51	**Saratoga County** Mechanicville	2308	**Thunderstorm Wind**
52	**Albany County** New Scotland	2311	**Thunderstorm Wind**
53	**Washington County** White Creek	2312	**Hail (1.75)**
54	**Bennington County** Shaftsbury	2315	**Hail (1.75)**
55	**Rensselaer County** 1.5 NNW East Schodack to 3.4 ENE Millers Corner	2322 2332	**Tornado (F2)**
56	**Albany County** New Scotland	2330	**Thunderstorm Wind**
57	**Greene County** Greenville	2333	**Thunderstorm Wind**
58	**Schoharie County** Schoharie	2335	**Thunderstorm Wind**
59	**Washington County** Greenwich	2335	**Thunderstorm Wind**
60	**Greene County** New Baltimore	2340	**Thunderstorm Wind**
61	**Rensselaer County** Stephentown	2342	**Hail (0.75)**

Rpt #	Location	Time (UTC)	Storm Characteristic
62	**Greene County** Catskill	2345	**Hail (0.75)**
63	**Windham County** Brattleboro	2355	**Thunderstorm Wind**
64	**Berkshire County** North Adams	2355	**Thunderstorm Wind (G 61)**
65	**Berkshire County** Great Barrington	0000	**Hail (0.75)**
66	**Ulster County** Saugerties	0000	**Thunderstorm Wind**

Storm Data for ALY CWA from 1930 UTC 5/31/98 through 0000UTC on 6/1/98



II. BGM CWA Reports

Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Otsego County**		
	Cooperstown to	1930	**Thunderstorm Wind**
	Burlington Flats	1940	

Severe thunderstorms produced widespread damage across the county. Trees and wires were blown down in Cooperstown and northern Burlington Flats between 3:30 and 3:40 pm EDT. Several roads were blocked due to the downed trees and wires. People were trapped in their vehicles by falling trees and some sustained injury from flying debris, broken glass, or falling wires.

Rpt #	Location	Time (UTC)	Storm Characteristic
2	**Chemung County**		
	Horseheads	1935	**Thunderstorm Wind**

A severe thunderstorm developed over the county during the afternoon and blew down trees and wires in Horseheads at 3:35 pm EDT.

Rpt #	Location	Time (UTC)	Storm Characteristic
3	**Chenango County**		
	Sherburne	2015	**Thunderstorm Wind**

Severe thunderstorms moved across the county during the afternoon blowing down trees that blocked roads in Sherburne at 4:15 pm EDT.

Rpt #	Location	Time (UTC)	Storm Characteristic
4	**Steuben County**		
	Hornell to	2020	**Hail (1.75)**
	Addison	2027	

A severe thunderstorm moving across the county produced large hail ranging from 3/4 to 1 3/4 inches in diameter in Hornell, Addison, and Andover between 4:20 and 4:27 pm EDT. Several automobiles had cracked or smashed windows from the falling hailstones near Andover as sizes grew to that of a golf ball.

Rpt #	Location	Time (UTC)	Storm Characteristic
5	**Otsego County**		
	Cooperstown to	2030	**Thunderstorm Wind**
	Oneonta	2050	

Severe thunderstorms moved across the county during the afternoon. Trees and wires were blown down in Cooperstown and Laurens between 4:30 and 4:35 PM EDT. Numerous trees and wires were also downed by the wind in Schenevus at 4:45 pm and Oneonta at 4:50 pm EDT. Transmission towers and large signs were also toppled in Oneonta. Numerous roads were blocked due to the downed trees and many of them were closed for several hours.

In Oneonta, a 32 year-old man was struck and killed by a large tree limb. Several additional injuries were sustained from flying debris.

Rpt #	Location	Time (UTC)	Storm Characteristic
6	**Cortland County**		
	Cuyler	2035	**Hail (0.75)**

A thunderstorm briefly reached severe limits and produced dime-sized hail in Cuyler.

Rpt #	Location	Time (UTC)	Storm Characteristic
7	**Chemung County**		
	Elmira Heights to	2040	**Hail (1.50)**
	Breesport	2110	

A severe thunderstorm dumped large hail from the Elmira/Elmira Heights vicinity eastward to near Breesport. Hailstones approaching golf-ball-size severely dented cars in a used automobile lot and cracked a few windshields.

Rpt #	Location	Time (UTC)	Storm Characteristic
8	**Delaware County**		
	Davenport to	2045	**Tornado (F0)**
	Fergusonville	2055	

A supercell thunderstorm briefly became tornadic as it crossed northern portions of the county late in the afternoon. The tornado cut a discontinuous 3 mile path from Davenport Township northeastward through Butts Corners to Fergusonville between 4:45 and 4:55 pm EDT.

The twister appeared to skip across mainly hilltop sections. Large trees were twisted and snapped off on ridge tops with tree damage mainly confined to canopy level at somewhat lower elevations. In Butts Corners, several homes near near the path of the tornado sustained siding and roof damage.

The tornado appeared to lift back into the cloud base just north of Route 9 in Fergusonville.

Rpt #	Location	Time (UTC)	Storm Characteristic
9	**Steuben County**		
	Hornell to	2110	**Thunderstorm Wind/Hail**
	Woodhull	2155	

Severe thunderstorms crossed the county late in the afternoon and caused widespread wind damage and also produced large hail. Many large trees and utility poles were knocked down in an east to west path from Hornell to Bath between 5:10 and 5:30 pm EDT. Golf-ball-sized hail was also observed along much of this path. By around 5:55 pm, the northern edge of the storm had weakened and slowed in it movement. At the same time, the southern end of the squall line became dominant. More trees were toppled in southern portions of the county around this time near Jasper and Woodhull.

Rpt #	Location	Time (UTC)	Storm Characteristic
10	**Onondaga County**		
	Marcellus	2112	**Thunderstorm Wind**

A severe thunderstorm moving across the county blew down trees in Marcellus at 5:12 pm EDT.

Rpt #	Location	Time (UTC)	Storm Characteristic
11	**Tioga County**		
	Barton to	2120	**Thunderstorm Wind/Hail**
	Newark Valley	2135	

Severe thunderstorms ripped through the county between 5:20 and 5:40 pm EDT. Downed trees and power lines were the result countywide with isolated roof damage to homes just west of Owego. Also, golf-ball-sized hail was observed in Newark Valley. Automobile and crop damage was inflicted by the falling hailstones. Hunderes of acres of crops at local fruit stands were severely damaged.

Rpt #	Location	Time (UTC)	Storm Characteristic
12	**Tioga County**		
	Apalachin	2130 2135	**Tornado (F0)**

A supercell thunderstorm became tornadic across extreme southeastern sections of the county. A tornado touched down in the town of Apalachin around 5:30 pm EDT just west of the Tioga/Broome county line. The tornado skipped along hilltop sections, snapping off trees along its path and causing considerable damage to the back porch of a house. The storm then pushed eastward into Broome County and continued to intensify.

Rpt #	Location	Time (UTC)	Storm Characteristic
13	**Broome County**		
	Vestal to Sanford	2135 2245	**Tornado (F3)**

A tornadic supercell ripped across southern sections of the county between approximately 5:35 pm and 6:45 pm EDT. Tornado intensities varied from F0 to F3 along this path. Hailstones as large as baseballs and tea cups were also observed along the cell's southern and western flanks.

A tornado which affected Apalachin in southeastern Tioga County crossed the county line and into the Town of Vestal around 5:35 pm EDT. At this point, the tornado was rated as F0 intensity with the width of the damage path around 70 yards. Damage was primarily to trees with some large trees uprooted and/or twisted off over hilltop secions. As the cell moved further east in the Town of Binghamton, the tornado intensified to category F2 with the damage width increasing to around 100 yards. In this location, the damage became increasingly severe with more structures affected. The local ABC affiliate in the Town of Binghamton sustained major damage. A 1000 foot television tower was twisted and toppled to the ground. A large trash dumpster was lifted off the ground and tossed into two satellite dishes, then thrown about 100 yards further over an embankment. A sport utility vehicle was rolled over several times as witnessed by a television crew member. Another vehicle was also moved and a video tape was carried over a mile-and-a-half away from the station. Several small trailers were also flattened in Binghamton just east of Ingraham Hill and others had minor roof damage. Two serious injuries occurred when a trailer collapsed upon the two female occupants who were in the kitchen at the time.

Between approximately 6:20 pm and 6:45 pm EDT, the tornado moved further east through Conklin, Kirkwood, Windsor, and eventually to the Sanford/Deposit area. In the Towns of Conklin and Kirkwood, the tornado maintained an F2 intensity. More than a dozen homes took on damage as the twister moved through. For the majority of these residences, damage was restricted to shingles and/or portions of the siding torn off or damaged from falling trees. However, there were several trailers that were nearly or completely destroyed within the direct path of the tornado in the Town of Conklin. For one such trailer, its wreckage was strewn downstream for more than a quarter of a mile. As the twister moved in the Town of Windsor, it briefly weakened to F0 intensity. At that point, touchdown locations appeared to be restricted to a few scattered spots with damage consisting of tree tops snapped or twisted off.

Once the tornado reached the Town of Sanford, it reintensified and reached category F3. A well built house was totally destroyed. The only part of the structure left standing was a small interior closet. Also, a wide swath of trees were flattened near a power company substation. Trees were twisted off and blown in all directions with hundreds of them estimated to be toppled. Local residents observed hail to 3 inches in diameter near the path of the tornado. Fortunately, as the twister reached its greatest intensity, it affected areas that were more sparsely populated.

Rpt #	Location	Time (UTC)	Storm Characteristic

In all, county emergency management officials estimated damage totals near 1.5 million dollars. Dozens of structures were severely damaged or destroyed and thousands of trees were cut down. Twelve injuries were sustained in total with very fortunately no loss of life. In some of the more remote areas, it took the better part of a week to restore power. Two of the three local television affiliates were knocked off the air for a time on the evening of the 31st with several radio stations also suffering through service interruptions for up to three days. The Towns of Binghamton, Conklin, and Sanford were put under a local state of emergency and also ultimately declared federal disaster areas.

Rpt #	Location	Time (UTC)	Storm Characteristic
14	**Chenango County** Plymouth	2150	**Tornado (F2)**

A supercell thunderstorm became tornadic near Plymouth Reservoir in Plymouth Township around 5:50 pm EDT. Although the tornado's touchdown was brief, it still cut a large swath of damage nearly a 1/4 mile wide and mowed down hundreds of trees around the reservoir. A few homes on the outer fringes of the tornado's sphere of influence had roof and siding damage.

Rpt #	Location	Time (UTC)	Storm Characteristic
15	**Cortland County** Cincinnatus	2152	**Thunderstorm Wind**

A thunderstorm quickly intensified to severe limits late in the afternoon over eastern portions of the county. Numerous trees were blown down in Cincinnatus at 5:52 pm EDT.

Rpt #	Location	Time (UTC)	Storm Characteristic
16	**Otsego County** Unadilla	2152	**Thunderstorm Wind**

A severe thunderstorm developed across southern portions of the county and blew down numerous trees in Unadilla around 5:52 pm EDT.

Rpt #	Location	Time (UTC)	Storm Characteristic
17	**Madison County** Cazenovia to Madison	2155	**Thunderstorm Wind**

A cluster of severe thunderstorms moved across the county during the afternoon. Numerous trees and wires were blown down across the county at approximately 5:55 pm EDT.

Rpt #	Location	Time (UTC)	Storm Characteristic
18	**Chenango County** North Norwich	2200	**Tornado (F0)**

A supercell thunderstorm became tornadic briefly over North Norwich around 6:00 pm EDT. Trees were snapped off and twisted in all directions along the tornado's path. Several road signs were also blown over and a few homes sustained roof and siding damage.

Rpt #	Location	Time (UTC)	Storm Characteristic
19	**Onondaga County** Nedrow to Manlius	2200 2245	**Thunderstorm Wind/Hail**

A cluster of severe thunderstorms moved across the county during the late afternoon and early evening. Transmission towers were blown down in Nedrow close to 6:00 pm EDT. Numerous trees and wires were also blown down countywide between 6:00 and 6:45 pm EDT with isolated damage occurring to homes. Dime-sized hail was observed in Camilus and Manlius between 6:35 and 6:45 pm EDT.

Rpt #	Location	Time (UTC)	Storm Characteristic
20	**Schuyler County**		
	Mecklenburg	2206	**Thunderstorm Wind**

A severe thunderstorm downed several large trees and power lines in Mecklenburg as it passed through shortly after 6:00 pm EDT.

21	**Seneca County**		
	Waterloo	2207	**Thunderstorm Wind**

A cluster of developing severe thunderstorms moved through central and southern portions of the county. Numerous trees and wires were downed in Waterloo at approximately 6:07 pm EDT.

22	**Cayuga County**		
	Auburn	2215 2230	**Thunderstorm Wind**

A severe thunderstorm blew down large trees and limbs in Auburn between 6:15 and 6:30 pm EDT.

23	**Luzerne County**		
	Shavertown to 1 SW Avoca	2215 2218	**Thunderstorm Wind/Hail**

Severe thunderstorms moving across the county produced nickel- to golf-ball-sized hail in Pittston, Dupont, and Shavertown between 6:15 pm and 6:18 pm EDT. Many trees and power lines were also downed. Two vehicles were pinned underneath large tree branches in Pittston and sustained heavy damage.

24	**Otsego County**		
	Portlandville to Maryland	2225 2230	**Tornado (F0)**

A severe thunderstorm briefly became tornadic early in the evening as it crossed over the ridges of the Crumhorn Mountains and into the Portlandville/Maryland area.

Damage consisted of tree tops twisted off in about a 30 yard wide area. The path of the twister was around three quarters of a mile with the intensity rated as F0. Just beyond Morehouse Brook in Maryland Township, the tornado appeared to lift back into the cloud base with no visible signs of damage downstream.

25	**Tioga County**		
	Tioga Terrace to Apalachin	2225 2230	**Thunderstorm Wind**

A severe thunderstorm produced wind damage in the southeastern portion of the county between 6:25 and 6:30 pm EDT.

Many large trees were downed across roadways and power lines in Tioga Terrace. Also, more trees were toppled in Apalachin with a radio tower damaged in South Apalachin.

26	**Bradford County**		
	New Albany	2225	**Thunderstorm Wind**

Rpt #	Location	Time (UTC)	Storm Characteristic

A thunderstorm briefly reached severe limits across southern portions of the county. Trees and wires were downed in New Albany around 6:25 pm EDT.

27	**Lackawanna County**		
	Old Forge	2227	**Thunderstorm Wind/Hail**

Severe thunderstorms moving across the county produced between 3/4- and 2-inch diameter hail in Old Forge at 6:27 pm EDT. Vehicles had cracked and/or smashed windshields from the largest hail. Also, wind damage was observed in the form of fallen trees and downed utility poles.

28	**Madison County**		
	Cazenovia to	2230	**Thunderstorm Wind**
	Brookfield	2250	

A cluster of severe thunderstorms moving across the county blew down trees and wires in Cazenovia at 6:30 pm EDT. Damage to a barn and mobile home was sustained in Brookfield by these storms at 6:50 pm EDT.

29	**Otsego County**		
	Laurens to	2230	**Tornado (F3)**
	Milford	2235	

A supercell thunderstorm became tornadic as it crossed southern portions of the county around 6:30 pm EDT. The storm cut nearly a 5-mile path from Laurens eastward into Milford Township.

This twister incurred major damage to heavily forested areas. Thousands of trees were laid out with the width of damage varying up to nearly a half mile in spots. Trees were blown over in a chaotic and almost circular pattern as viewed from aerial damage surveys. Several homes within the path of the twister also sustained heavy damage. In the Town of Laurens, a well built home was nearly destroyed with only a back and a portion of the side wall left intact. Many local roads were closed for up to 3 days as fallen trees made them completely impassable. This included portions of Routes 12 and 44.

The cell appeared to weaken as it approached Interstate 88 just east of Milford.

County emergency officials estimated damage totals in excess of three quarters of a million dollars from this twister. Most of ti stemmed from deforestation, repair of utility poles, and other repairs to homes and public structures. Three minor injuries were sustained from falling tree limbs and flying debris.

30	**Delaware County**		
	Deposit to	2245	**Tornado (F3)**
	Downsville	2340	

The same tornadic supercell that moved through southern portions of Broome County crossed into Delaware County in Deposit around 6:45 pm EDT. At that point, the tornado was still quite strong and maintained an intensity of category F3. Several more homes were severely damaged as the twister moved over Route 8 and areas just west of Cannonsville Reservoir. Again, large swaths of trees were cut down and hail larger than baseballs were observed.

Rpt #	Location	Time (UTC)	Storm Characteristic

Once the cell passed on to the east across Tompkins and Colchester Townships, it weakened as tornado intensity decreased to F1. Significant tree damage was seen in both ground and aerial damage surveys along hilltop areas just north and east of Cannonsville Reservoir. Hundreds of tree tops were estimated to be twisted off with several utility poles also taken out in these areas.

Further east towards Downsville, tornado intensity fluctuated between F0 and F1 with most of the damage to trees along ridge tops. Fortunately, the twister skipped along sparsely populated areas for the most part. As a result, structural damage and injuries were kept to a minimum. Once the cell reached the eastern end of Pepacton Reservoir, it weakened further with the tornado apparently lifting back into the cloud base.

Emergency management officials estimated damage totals approaching a million dollars. The majority of the damage occurred in Deposit. The town of Deposit was placed under a local state of emergency for several days with this area also eventually receiving federal aid.

31	**Broome County**		
	Countywide	2250 2315	**Thunderstorm Wind/Hail**

Supercell thunderstorms continued to redevelop across the county during the early evening hours. These storms produced wind damage and large hail over a widespread area.

Hail to baseball size in diameter dented automobiles and damaged crops from the south side of Binghamton to Conklin and Windsor between 7:00 and 7:15 pm EDT. Trees were also downed in Chenango Forks, Endwell, Vestall, and Port Dickinson.

32	**Wayne County**		
	Sterling	2250 2300	**Thunderstorm Wind/Hail**

Severe thunderstorms moving across the county produced 1-to-2-inch hail between 6:50 and 7:00 pm in Sterling Township. Siding damage to a house was incurred from the falling hailstones. In addition, strong winds downed numerous trees and wires just before 7:00 pm EDT.

33	**Luzerne County**		
	2 NE Pittston	2300	**Tornado (F0)**

A severe thunderstorm intensified and briefly became tornadic over Jackson Township in eastern portions of the county around 7:00 pm EDT.

Eyewitnesses reports and damage surveys indicate tree tops were twisted off and a few utility poles were sheared off. The pattern of the damage was chaotic with tree limbs in many directions. The tornado appeared to be near ground level for only a brief time before it lifted back into the cloud base. Fortunately, it touched down away from more populated areas.

34	**Chemung County**		
	Horseheads	2322	**Thunderstorm Wind**

A thunderstorm briefly reached severe levels as it downed trees and power lines in and just outside of Horseheads shortly before 7:30 pm EDT.

35	**Tioga County**		
	Apalachin	2330	**Thunderstorm Wind**

Rpt #	Location	Time (UTC)	Storm Characteristic

A thunderstorm intensified to severe limits over southeastern portions of the county. Several large trees were toppled in Apalachin around 7:30 pm EDT.

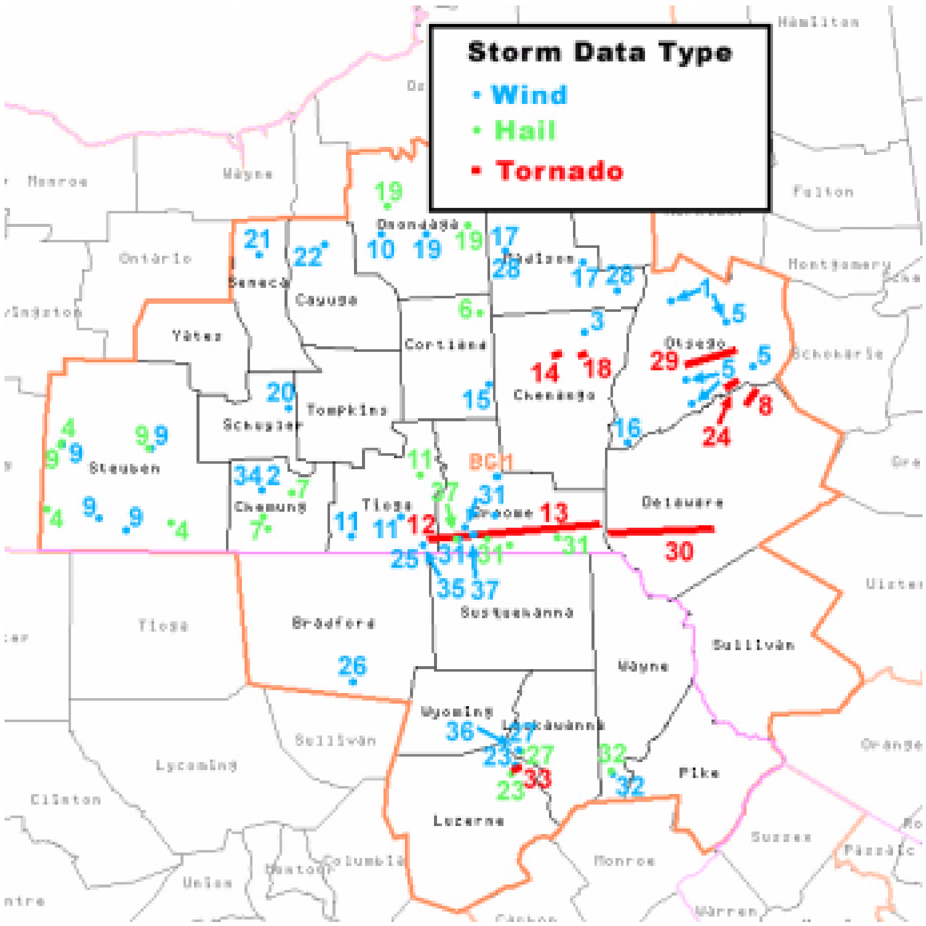
36	**Lackawanna County**		
	Old Forge	2335	**Thunderstorm Wind**

Severe thunderstorms downed trees and wires in Old Forge at 7:35 pm EDT.

37	**Broome County**		
	Vestal to	2350	**Thunderstorm Wind/Hail**
	Windsor	0050	

The severe thunderstorm that produced wind damage in southeastern Tioga County a bit earlier in the evening also dropped large hail in the southwestern corner of Broome County. Golf-ball-sized hail was observed in Vestal by a Skywarn spotter about 7:50 pm EDT. In addition, wind damage was inflicted in many communities after 8:00 pm EDT. Trees and wires were downed in Johnson City, Chenango Bridge, and Colesville between 8:00 and 8:30 pm EDT. Also, a few trees were toppled onto utility poles in Windsor between 8:40 and 8:50 pm EDT.

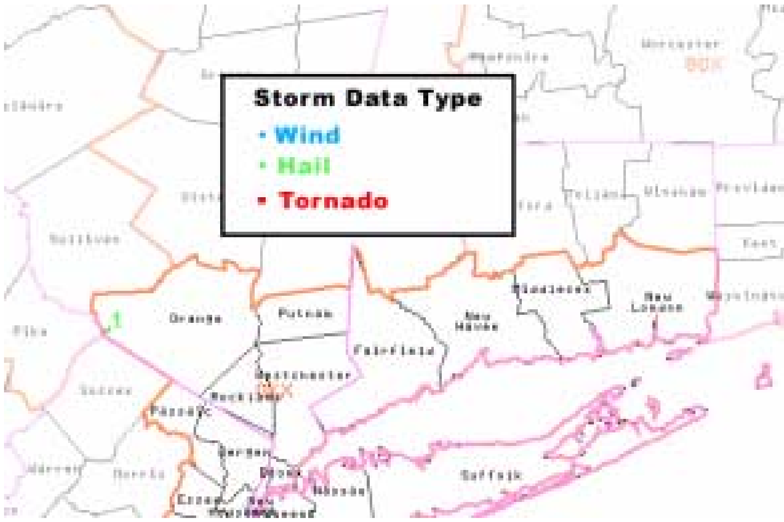
Storm Data for BGM CWA from 1930 UTC 5/31/98 through 0000 UTC on 6/1/98



III. OKX CWA Storm Reports

Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Orange County** Port Jervis	2350	**Hail (1.50)**

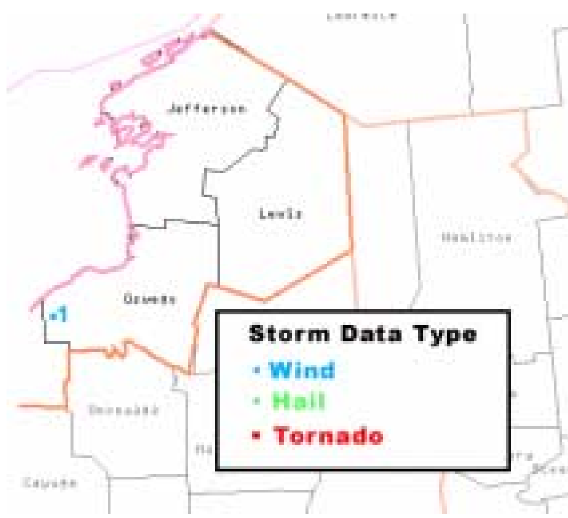
Storm Data for OKX CWA from 1930 UTC 5/31/98 through 0000 UTC on 6/1/98



IV. BUF CWA Storm Reports

Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Oswego County** Hannibal	2010	**Thunderstorm Wind**

Storm Data for BUF CWA from 1930 UTC 5/31/98 through 0000 UTC on 6/1/98

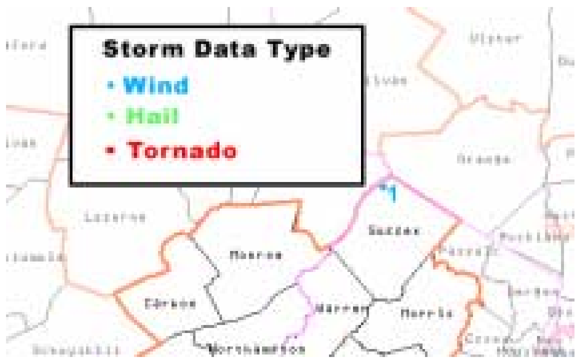


V. PHI CWA Storm Reports

Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Sussex County** Montague	2348	**Thunderstorm Wind**

A severe thunderstorm knocked down trees in Montague Township. This was the first of three severe thunderstorms to affect Sussex County the evening of 31st.

Storm Data for PHI CWA from 1930 UTC 5/31/98 through 0000 UTC on 6/1/98



VI. BTV CWA Storm Reports

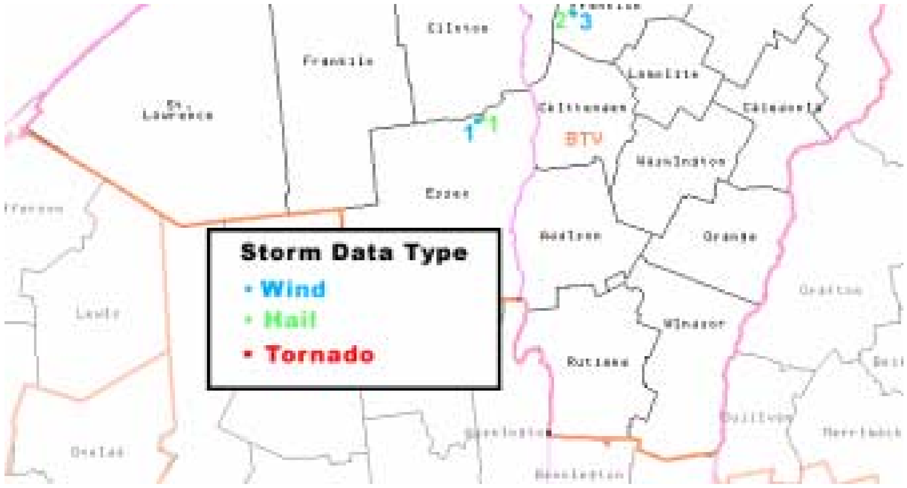
Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Essex County** Ausable Forks	2000	**Thunderstorm Wind/Hail**

An area of strong low pressure moved across southern Canada during Sunday, May 31st. Thunderstorms and showers with gusty winds, small hail and very heavy rain moved across the county. Marble-sized hail was reported in Ausable Forks around 3 pm EST.

Rpt #	Location	Time (UTC)	Storm Characteristic
2	**Franklin County** St. Albans	2122	**Hail (0.75)**
3	**Franklin County** St. Albans	2122	**Thunderstorm Wind (G 60)**

An area of strong low pressure moved across southern Canada during Sunday, May 31st. Thunderstorms and showers with gusty winds, hail and very heavy rain moved across the county. In St. Albans, Vermont, 3/4-inch hail was reported and winds of 60 mph (52 knots) blew down trees. Frequent cloud-to-ground lightning was also reported.

Storm Data for BTV CWA from 1930 UTC 5/31/98 through 0000 UTC on 6/1/98



Appendix B: SPC Products

I. Day 1 Convective Outlook

ZCZC MKCSWODY1 000
ACUS1 KMKC 311446
_MKC AC 311446

CONVECTIVE OUTLOOK...REF AFOS NMCGPH94O.

VALID 311500Z - 011200Z

REF WW NUMBER 0475...VALID TIL 1900Z
REF WW NUMBER 0476...VALID TIL 1900Z

THERE IS A HIGH RISK OF SVR TSTMS FOR PTNS OF SRN AND ERN NY...NRN AND CENTRAL PA...NRN NJ...EXTREME WRN VT...EXTREME WRN MA...TO THE RIGHT OF A LINE FROM 25 W MPV 15 S RUT 20 W BAF 20 W BDR 25 ENE ABE 25 NW CXY PIT 15 ESE FKL 10 NNW BFD 30 NW ITH 30 SE ART 20 S SLK 25 W MPV.

THERE IS A MDT RISK OF SVR TSTMS TO THE RIGHT OF A LINE FROM 35 N BML 20 W BOS 20 WSW GON TTN HGR 25 NNW SHD 30 W TRI 40 NE DYR 15 N PAH EVV 40 E BMG 35 S FDY 15 WNW CLE.

THERE IS A SLGT RISK OF SVR TSTMS TO THE RIGHT OF A LINE FROM 30 NNE HAT 30 ESE RWI 25 NW SOP AVL CHA 20 N MSL 20 NE MEM ARG 45 SW BLV DNV 30 S SBN 20 S DTW.

GEN TSTMS ARE FCST TO THE RIGHT OF A LINE FROM 35 SW HUM GPT 45 SSW SEM 25 S AUO ANB 20 S MSL UOX 30 ESE PGO MLC 20 NW MKO UMN JEF UIN CID 20 SSW MCW 30 NNW OMA 10 N GRI 25 SE MCK 50 ENE 4LJ 20 W LIC LAR 15 SE RKS SLC U31 35 WSW BIH 15 N SAC 30 W MHS 30 ESE SLE PDT 30 E EPH 45 ENE BLI ...CONT... 35 NNE CTB LWT 30 SSE MLS 25 ESE REJ 15 ESE P05 40 SW MHE 30 NE FSD AXN TVF 65 W D45.

STRONG SHORTWAVE TROUGH EXTENDING FROM UPPER LOW OVER HUDSON BAY WILL MOVE RAPIDLY EASTWARD ACROSS THE NERN STATES TODAY. A STRONG MID LEVEL JET IS ASSOCIATED WITH THIS TROUGH WITH A SECONDARY JET

MAX EXPECTED TO MOVE SEWD ACROSS THE OH VALLEY LATER THIS AFTERNOON.

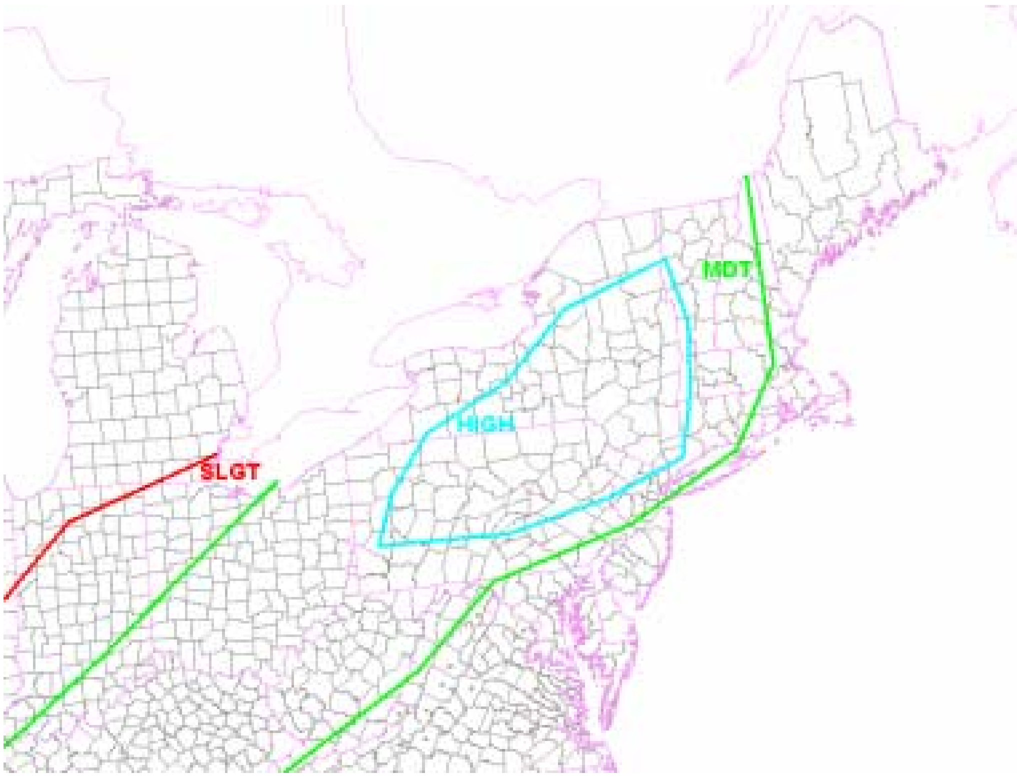
AT THE SURFACE...LOW PRESSURE OVER LAKE HURON WILL RAPIDLY DEEPEN AS IT MOVES INTO ONTARIO WHICH WILL ALLOW A WARM FRONT TO LIFT NWD ACROSS NEW ENGLAND. INTENSE MCS OVER LAKE HURON HAS WEAKENED SOMEWHAT THIS MORNING...BUT SHOULD REINTENSIFY BY EARLY AFTEROON AS AIRMASS RECOVERS. IN ADDITION...OUTFLOW BOUNDARY ALONG THE SOUTHERN END OF THE LINE WILL EXTEND ACROSS PORTIONS OF SRN NY/NRN PA AND ERN OH PROVIDING AN ADDITIONAL FOCUS FOR THUNDERSTORM DEVELOPMENT THIS AFTERNOON. STRONG WIND FIELDS AT ALL LEVELS INDICATE A DISTINCT THREAT FOR WIDESPREAD DAMAGING WINDS. IF MORE CELLULAR CONVECTION CAN DEVELOP...HELICITY AND STORM RELATIVE FLOW APPEAR FAVORABLE FOR ISOLATED SUPERCELL TORNADOES.

FARTHER SW ACROSS THE OH VALLEY...ADDITIONAL THUNDERSTORMS WILL DEVELOP ALONG COLD FRONT THIS AFTERNOON AS CAP BREAKS. ALTHOUGH IT IS EXPECTED TO BE RATHER WARM ALOFT...STRONG HEATING AND DEWPOINTS IN THE LOWER 70S WILL ALLOW FOR MODERATE INSTABILITY. SHEAR WILL INCREASE SUBSTANTIALLY THIS AFTERNOON AS 60 KT MID-LEVEL JET MAX MOVES ACROSS THE AREA. THUS...THUNDERSTORMS THAT DEVELOP WILL RAPIDLY BECOME SEVERE WITH THE POTENTIAL FOR DAMAGING WINDS AND ISOLATED TORNADOES. ACTIVITY MAY EVOLVE INTO A SQUALL LINE THIS EVENING AND MOVE TOWARD THE CENTRAL/SRN APPALACHIANS.

..VESCIO.. 05/31/98

NNNN

1528 UTC Convective Outlook on 05/31/98



II. Tornado Watches

ZCZC MKCSEL8 ALL 010000;412,0770 433,0762 433,0720 412,0730;
WWUS9 KMKC 311833
_MKC WW 311833
NYZ000-PAZ000-VTZ000-MAZ000-CTZ000-010000-

BULLETIN - IMMEDIATE BROADCAST REQUESTED
TORNADO WATCH NUMBER 478
STORM PREDICTION CENTER NORMAN OK
233 PM EDT SUN MAY 31 1998

THE STORM PREDICTION CENTER HAS ISSUED A
TORNADO WATCH FOR PORTIONS OF

CENTRAL AND EASTERN NEW YORK
NORTHEAST PENNSYLVANIA
SOUTHERN VERMONT
WESTERN MASSACHUSETTS

NORTHWEST CONNECTICUT

EFFECTIVE THIS SUNDAY AFTERNOON AND EVENING FROM 300 PM UNTIL 800 PM EDT.

TORNADOES...HAIL TO 2 INCHES IN DIAMETER...THUNDERSTORM WIND GUSTS TO 80 MPH...AND DANGEROUS LIGHTNING ARE POSSIBLE IN THESE AREAS.

THE TORNADO WATCH AREA IS ALONG AND 105 STATUTE MILES EAST AND WEST OF A LINE FROM 20 MILES SOUTHWEST OF MONTICELLO NEW YORK TO 35 MILES WEST NORTHWEST OF GLENS FALLS NEW YORK.

REMEMBER...A TORNADO WATCH MEANS CONDITIONS ARE FAVORABLE FOR TORNADOES AND SEVERE THUNDERSTORMS IN AND CLOSE TO THE WATCH AREA. PERSONS IN THESE AREAS SHOULD BE ON THE LOOKOUT FOR THREATENING WEATHER CONDITIONS AND LISTEN FOR LATER STATEMENTS AND POSSIBLE WARNINGS.

OTHER WATCH INFORMATION...THIS TORNADO WATCH REPLACES TORNADO WATCH NUMBER 475. WATCH NUMBER 475 WILL NOT BE IN EFFECT AFTER 300 PM EDT. CONTINUE...WW 476...WW 477...

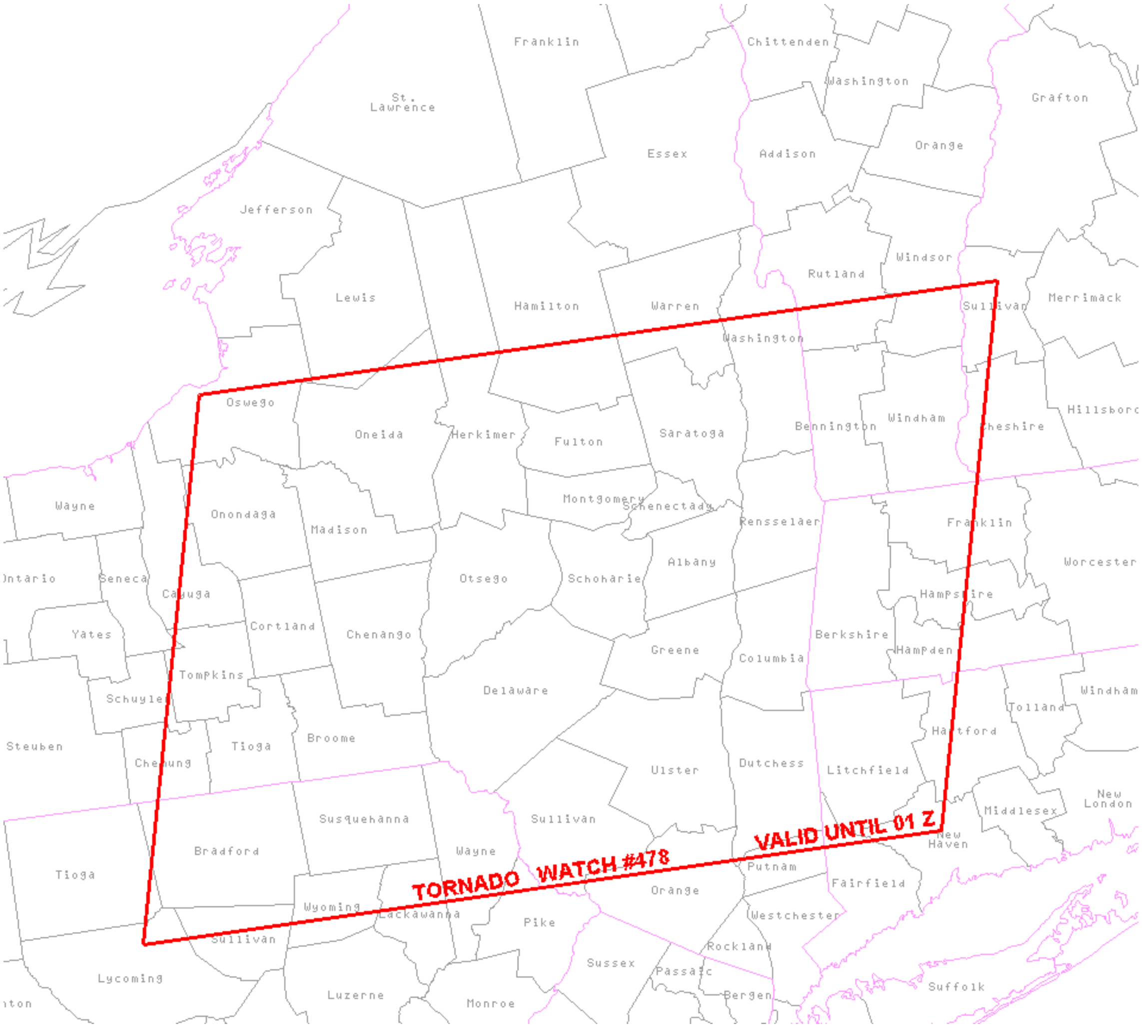
DISCUSSION...THUNDERSTORMS ARE REORGANIZING OVER THE SOUTHERN TIER OF NEW YORK. ACTIVITY LIKELY TO PRODUCE DAMAGING WINDS AND POSSIBLY AN ISOLATED TORNADO OR TWO AS IT MOVES RAPIDLY EASTWARD.

AVIATION...TORNADOES AND A FEW SEVERE THUNDERSTORMS WITH HAIL SURFACE AND ALOFT TO 2 INCHES. EXTREME TURBULENCE AND SURFACE WIND GUSTS TO 70 KNOTS. A FEW CUMULONIMBI WITH MAXIMUM TOPS TO 500. MEAN STORM MOTION VECTOR 27040.

...VESCIO

;412,0770 433,0762 433,0720 412,0730;

NNNN



Tornado Watch #478

Appendix C: Support Materials

This Appendix includes:

A sample warning log provided for use in the simulations (see page C-2).

A map of the Albany CWA (see Figure C-2 on page C-3).

Warning Decision Training Branch

Team Members: **Warning Log** **Today's Date**

___________/___________ Simulation Location/Date ________________ Page #_____________

Warning Type
Tornado - T
Svr Tstm - S
Flash Flood - F
Svr Wx Statement - SVS
Nowcast - NOW

List Basis for Warnings (In order of importance):
1 - Reflectivity; 2 - SRM; 3- Base Velocity;
4 - MESO; 5- TVS; 6 - VIL; 7- Precip; 8 - Other Alg
9 - Loop; 10 - Report; 11 - Other (explain)

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

Figure C-1. Warning Log Form.

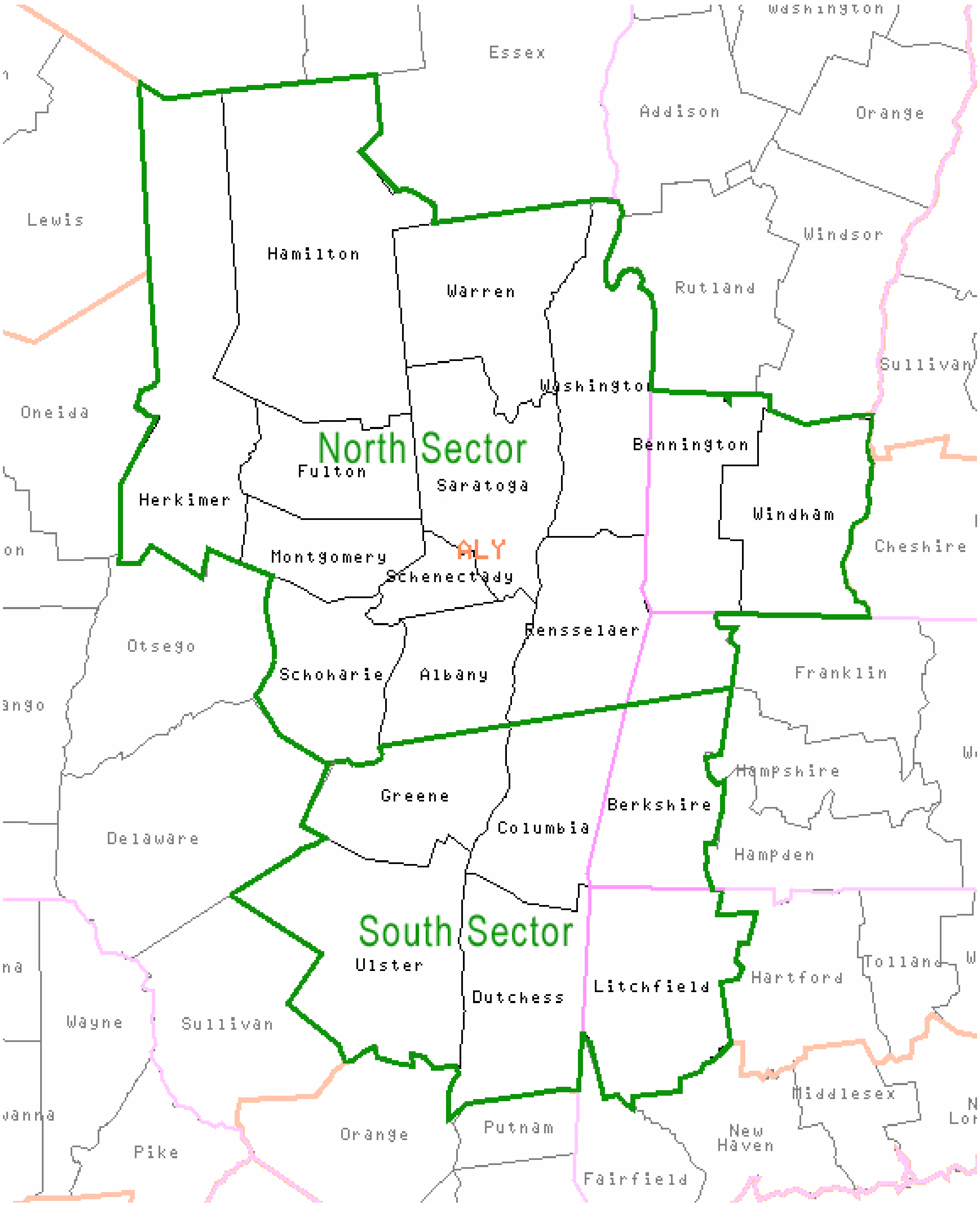


Figure C-2. A map of the Albany CWA. The simulations covering the time period from 2200 - 0000 UTC refer to the sectors illustrated here.